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THE ECONOMIC EFFECTS OF POLLUTION ABATEMENT ON THE PULP AND PAPER INDUSTRY: RESULTS OF AN ECONOMETRIC STUDY

January 1980

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PREFACE TO THE SERIES

"Working Papers in Environmental Economics and Planning"

This report is the first in a new series, "Working Papers in Environmental Economics and Planning". This series has been established to disseminate the results of empirical research on the economic and social aspects of environmental issues. Four important trends have recently combined to make it necessary to now consider the economic consequences of environmental protection activities more explicitly and to employ economic and planning tools in developing new pollution control policies.

First of all, we are in a period of resource constraint which impinges upon all sectors of the economy and society. It is important, therefore, to be sure that pollution abatement activities are both rational (that the benefits are reasonably commensurate with the costs) and cost-effective (that objectives are being accomplished in a least-cost manner). As economics is the science of scarcity, economic analyses of environmental problems and policies constitute an important addition to environmental management methods.

The second factor that necessitates the use of more economic and planning techniques stems from the relative success we have had in implementing pollution control programs for most of the "point-source" waste emissions in the Province. However, where treatment and control systems are in place, the remaining pollution may cost as much or more to treat as did all that has been accomplished to date. Polluters who must bear these high added costs understandably object. Under these circumstances the benefits of the last increments of abatement may have to be more systematically evaluated.

Traditional environmental management approaches may not be appropriate in some instances. Priorities must, therefore, be established and careful planning of future land uses is essential to the control and resolution of these problems.

A third important reason why economic and planning tools must be utilized derives from the expanded definition of environment to include more than just air, water and land or the liquid, gaseous or solid wastes with which we have traditionally had to deal. In addition to these categories and to plants and animals, environment has been defined to include social, cultural and economic conditions, man-made structures and devices and any "heat, sound, vibration or radiation resulting directly or indirectly from the activities of man". In short, we must now be concerned with far more than just what is coming out of pipes, stacks or garbage trucks.

Given this widened definition of the environment, both economics and planning methodologies can provide an increased understanding of the interrelationships among the various components that make up this "new" environment. Moreover, environmental-economic trade-offs must be made involving a number of factors that are not easily quantified or compared. Nevertheless, benefit-cost and social impact analyses are being required at all levels of government so that the development of techniques to measure and evaluate these intangibles is imperative. For these techniques and the data to use them, we must turn to the social sciences as well as to the physical and applied sciences, such as biology and engineering.

Finally, a fourth issue arises from an increased awareness of environmental problems by the public and from the increasing expectations of citizens for a safe and clean environment. Ever since popular opinion polls on the subject have commenced, people have registered their desire for environmental quality and protection near the top of the priority lists. Governments are under pressure, therefore, to react to these expressed desires. However, governments must determine just how far they ought to go in enforcing environmental protection to satisfy public demands for this service. Some balancing of the costs of achieving environmental quality against the benefits must, in some instances, take place in order to avoid undue social disruptions.

Consequently, in order for both governments and the public to make better decisions from the plethora of facts, figures and opinions about what is wrong and what ought to be done, a more systematic and accessible ordering of information will be necessary. Planning and economic studies will yield a clearer picture of the implications and the consequences of the different possible courses of action. In particular, the economic, social and political costs of achieving public expectations and demands for environmental quality can be better identified. The assembly and dissemination to the public of information about the economic and social consequences of environmental management efforts should help understanding and gain acceptance of the difficult environmental-economic trade-offs that, in many cases, must be made.

The series has been established to provide access to well researched and documented studies that will contribute to our understanding of environmental problems and to suggest new ways of dealing with them.

It is hoped that this report will be useful to researchers and managers in both public and private sectors who have an active interest in the past effects and future consequences of government policy on the pulp and paper industry. Comments on this and future working papers will be welcomed.

J. W. Giles

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Working Papers in Environmental Economics and Planning

THE ECONOMIC EFFECTS OF POLLUTION ABATEMENT ON THE PULP AND PAPER INDUSTRY: RESULTS OF AN ECONOMETRIC STUDY

by

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JANUARY, 1980

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ACKNOWLEDGEMENTS

This work was supervised by J. A. Donnan, senior economist in the Ontario Ministry of the Environment and by Professor R. A. Muller of the Economics Department of McMaster University. Professor Muller's Econometric Model of the Canadian pulp and paper industry constituted the basic analytical tool for this study.

ABSTRACT

In this study, an econometric model of the Canadian pulp and paper (P & P) industry has been used to analyze the impact of pollution abatement costs on the industry. The model used here is a revised version of a model developed by R.A. Muller.* This model can be used to assess the impact of pollution abatement expenditures on production, employment, prices and capacity growth in the pulp and paper industry. The results of the simulations indicate what the effects would have been over the time period of the available data, 1958-1974.

The results of this study corroborate Professor Muller's earlier conclusion that the Canadian pulp and paper industry markets are not very sensitive to cost changes of the magnitude contemplated for pollution abatement (Muller, September 1975: pgs. 25-26). The effect of such cost increases on the Ontario industry depends crucially on whether abatement costs are imposed outside of Ontario as well as in the Province. When all producers face similar cost increases, Ontario producers are not likely to suffer significantly. Moreover, if the cost increases are held below 5%, then the impact on output and employment is small whether or not similar costs increases are experienced elsewhere.

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* R.A. Muller, "A Simulation of Adjustment to Pollution Control Costs in the Pulp and Paper Industry"' Unpublished Ph.D. Thesis, University of Toronto, Department of Economics, 1975.

PREFACE

Public enthusiasm for improvement in the quality of the natural environment has long been tempered by a fear that strictly enforced pollution controls might lead to widespread reductions in industrial output and massive losses of employment. Nowhere has this ambivalence been more evident than in the case of the pulp and paper industry, simultaneously the source of a large fraction of industrial wastes and of employment across the country.

Public recognition that pollution control may entail a loss of employment in some pollution intensive industries has made it easy for some to argue that the Ontario Government should not be quick to legislate mandatory levels of waste abatement for the pulp and paper industry nor to penalize companies whose effluent discharges fail to meet reasonable water quality standards. The strength of these objections to the pursuit of improved water quality cannot be evaluated without some evidence as to the probable magnitude of the output and employment effects to be expected when industrial costs rise due to pollution abatement expenditures. This present study represents a valuable contribution to our meagre stock of empirical work on this issue.

Mike Fortin has imaginatively extended my own previous work to construct an econometric model of the Canadian pulp

and paper industry and its Ontario sector. This model is capable of analyzing the effect of cost changes in Ontario alone, in the rest of Canada, and in all of North America. It is gratifying to see my initial approach extended in such a thoroughly competent manner.

The empirical issues surrounding the imposition of pollution control cannot be resolved by one study alone. Other approaches to the issue are possible, particularly those which focus on the nature of interregional competition more closely than does the present model. I hope that other studies of the pulp and paper industry will be undertaken; studies which could serve to confirm or modify the conclusions reached by Mike Fortin. In the meantime, however, his study represents a significant advance in our ability to cast this policy issue into quantitative terms. I commend it to all those involved in formulating environmental policy.

R.A. Muller

October, 1977

INTRODUCTION

In this study, an econometric model of the Canadian pulp and paper (P & P) industry has been used to analyze the impact of pollution abatement costs on the industry.[1] The results of this analysis suggest that added pollution abatement costs will not cause Ontario pulp and paper mills to lose sales or jobs as long as pulp and paper mills in the rest of Canada or the United States incur similar pollution abatement costs. Studies commissioned by the International Joint Commission indicate that pulp and paper mills have had to achieve a greater degree of pollution abatement in the U.S. than they have in Canada and Ontario.[2] Indeed, the results of the simulations accomplished in this study indicate that the impact of abatement costs on the industry in Ontario might be significant only if:

1. these costs exceed 5% of total industry costs; and
2. they are imposed only on Ontario producers and not on producers elsewhere in Canada or the U.S.

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1 The model was designed by Professor R.A Muller of McMaster University (Muller, 1975). This paper draws heavily from his design, his analytical methodology, and the many suggestions he personally has offered in the course of this current work.

2 The Great Lakes Water Quality Board of the International Joint Commission published the results of a study that compared the environmental objectives for Ontario and the U.S. pulp and paper mills as well as the progress achieved by these industries toward reaching them. This study found that U.S. federal objectives were more stringent for BOD5, while Canadian federal guidelines are more stringent for suspended solids. Between 1967 and 1977 the U.S. mills exhibited a higher percentage reduction in both BOD_5 and suspended solids loadings than did mills in Ontario. International Joint Commission, Great Lakes Water Quality 1977 Annual Report, Windsor, Ont.: Great Lakes Water Quality Board, IJC, 1978, p.56.

This paper proceeds in the following manner. A brief description of econometric models in general, and of this model in particular, are given and the application of this model to policy analysis is described. Finally, the results of the analysis are presented.

In the Appendices, a formal description of the model is presented along with a discussion of the statistical techniques used, a listing of the data used in the model and a complete listing of policy analysis results.

PULP AND PAPER INDUSTRY MODEL

Econometric models are statistical tools used for empirical economic analysis. Their design begins with an initital conception of how decision-makers in the industry behave in response to changes within the industry and in the economy at large. The conception of behaviour embodied in the model constitutes the economic theory that is used. Like any useful theory, economic theory is a highly simplified rendition of the world and resulting models are necessarily quite stylized simplified versions of reality.

The economic theory postulates causal relationships. These relationships are then written mathematically in the form of equations. Price, for example, is specified as a function of such variables as last year's prices, production costs and the price of competing products:

$$\begin{aligned} \text{Price (this year)} \quad = \quad a \quad & + \quad a_1 \quad \text{x (price last year)} \\ & + \quad a_2 \quad \text{x (production costs)} \\ & + \quad a_3 \quad \text{x (competing prices)} \end{aligned}$$

Each variable on the right hand side is multiplied by some constant (a_1, a_2, a_3) which is called a parameter or a coefficient in the model. Parameters are estimated from the observed data for the variables using a statistical tool called regression analysis.[3] The full model consists of equations describing causation which contain:

a) Variables for which data are obtained by observation of the real world. The variables that comprise the model may change over time. The values of the variables change over time.

b) Parameters that indicate the relationship between the variables in each equation. Parameters are assumed to be constant through time.

The model used in this analysis is a modified version of the econometric model of the Canadian pulp and paper industry originally designed by Andrew Muller. The changes that were made to Muller's model are described in Appendix II. Diagram 1 illustrates the rationale that underlies the design of the model. The arrows specify casual links postulated for the industry in the model. The boxes within the dashed outline represent the principle components of economic activity in the P & P industry including demand for P & P products as well as various elements affecting supply and the market price. As is indicated by the arrows, all components interact with one another through indirect feedback loops. For example, one can trace the effect that a decision to install new equipment that increases capacity

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3 Regression analysis is a refined version of simple correlation analysis.

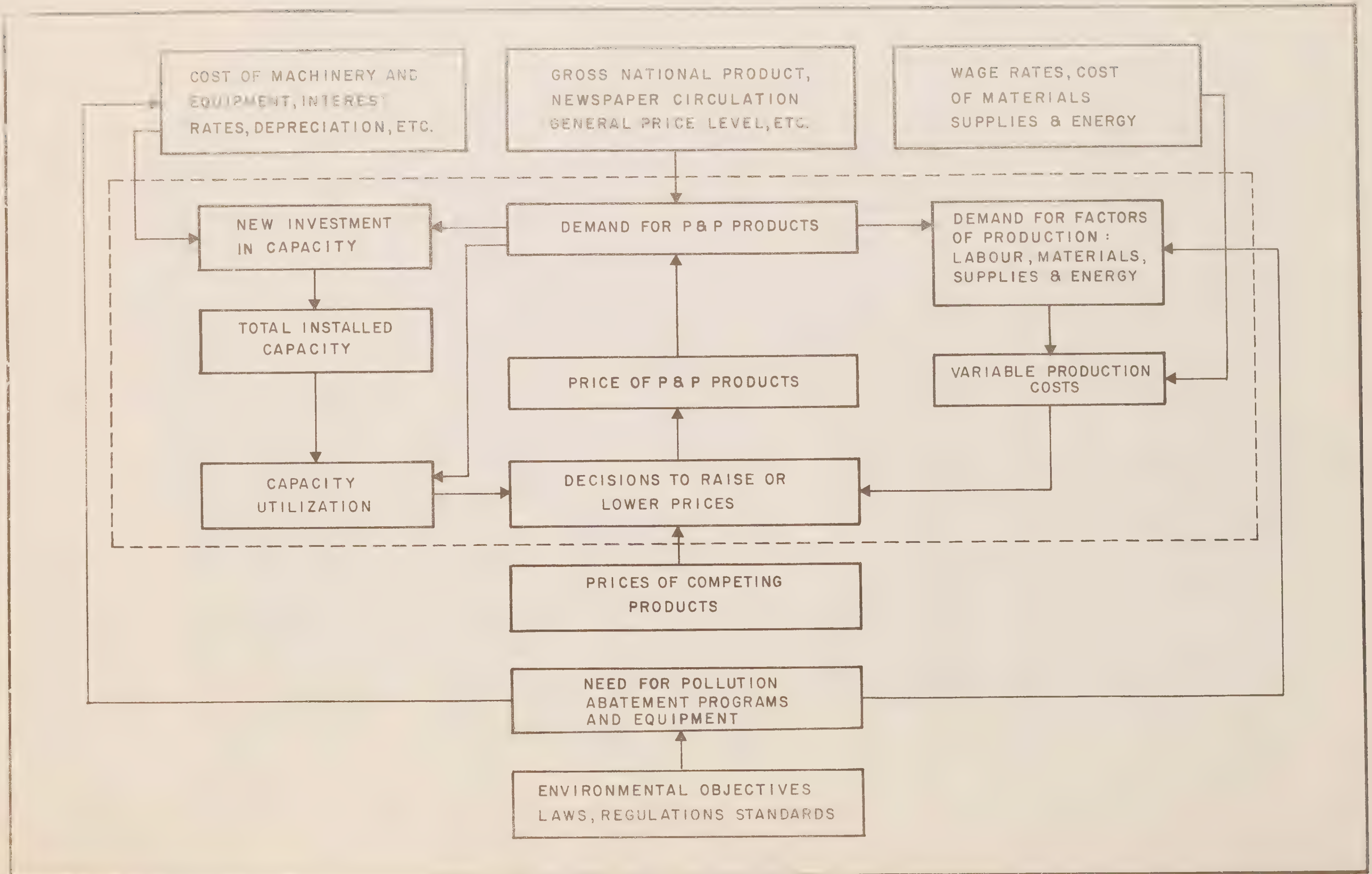

DIAGRAM I: SCHEMATIC REPRESENTATION OF THE PULP AND PAPER INDUSTRY BASED ON MULLER'S MODEL

will, in subsequent time periods, influence the degree to which industry productive capacity is being utilized. If capacity utilization is very high, management can raise prices with impunity. If capacity is seriously under-utilized, they will be reluctant to raise prices for fear of a loss of sales to competitors.

In Muller's model, variables within the dashed outline are determined within the model. They are called endogenous variables. The variables outside the outline have an affect on the industry but are not themselves noticeably influenced by the actions of industry. These are called exogenous variables. The values of individual exogenous variables are presumed not to be affected by the model.

The model builder decides which variables are endogenous and which are exogenous. These decisions, as well as the size and complexity of the model, depend in large measure on the intended function of the model. Time and budget available to the designer also influence the design of the model.

Muller's econometric model of the pulp and paper industry identifies the components of the industry's outputs and inputs. An important task of the current study is to incorporate a description of the industry on a regional basis.

Industry products are grouped into four categories for Canada:

1) newsprint - 45% of total output
2) other pulp and paper board - 23%
3) woodpulp exports - 25%
4) other products - 7%

and into three categories for Ontario:

1) newsprint - 32% of total output
2) other paper and paperboard - 38%
3) other products including woodpulp exports - 30%.

There are four measures of capacity:

1) American newsprint capacity
2) Canadian newsprint capacity
3) Canadian woodpulp capacity
4) Ontario newsprint capacity.

Apart from capacity, which is a measure of productive capital, the two other measures of industry factor inputs are:

1) labour (total number of employed production workers),
2) a composite index of the consumption of materials, supplies and energy.[4]

Newsprint is considered to be sold in a common North American market. Therefore, total market demand and the Canadian and Ontario market shares of this market must be estimated. Most woodpulp exports go to the United States while other paper and paperboard products are sold primarily

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[4] Data for these different variables are drawn from Statistics Canada publications and from reports of the Canadian Pulp and Paper Association.

in domestic markets. The level of demand for Canadian output and the Ontario share of output for pulp exports and domestic shipments of other paper and paperboard must be estimated.

The model can be used to explain how changes in the prices of North American newsprint, Canadian woodpulp and other paper and paperboard sold in Canada occur. On the other hand, prices paid by Canadian mills for labour, materials, energy, capital goods and American woodpulp as well as the prices of other paper and paperboard sold in the United States are exogenous variables and the present model cannot be used to determine them.

On the other hand, the prices of North American newsprint, domestic paper and board and Canadian woodpulp are endogenous variables and an important aspect of the model is how these prices are thought to be determined. Muller views the newsprint and Canadian paper and board markets as oligopolistic in nature (Muller, Sept. 1975, p.10). There are relatively few firms who take account of each other's activities, especially when it comes to setting prices.[5] A price leadership model was employed in specifying the newsprint price equation (Muller, Sept. 1975, p.11). Canadian firms are assumed to set prices

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[5] About 20 Canadian newsprint manufacturers supply over two-thirds of North American newsprint.

(quoted in U.S. dollars) on the basis of a target mark-up over operating costs. Prices for other paper and board sold in Canada are, to some extent, protected from foreign competition by tariffs, although the tariffs for these products have been declining over the past two decades.

Because Canadian woodpulp must compete in a tariff-free world market, prices are determined by an interaction of supply and demand forces. In Muller's model, woodpulp exports are assumed to be determined simultaneously with the unobserved Canadian net prices and world demand for North American woodpulp (see Muller, Sept. 1975, p.7).

Economic activity has an important temporal dimension. This model accounts for the element of time by allowing events of previous years to influence current activities. In this respect, the model is "dynamic". The time dimension is particularly evident in the decisions to change product prices and to invest in greater capacity. With respect to product prices, it is assumed that last year's price levels have a dampening effect on desired price changes in the current year. The time factor enters into investment decisions because of the long lead times needed to install new capacity. New capital goods coming on stream in the current year are the outcome of investment decisions made as long as two years ago and that were based on production costs and product demand of that period.

POLICY ANALYSIS METHODOLOGY

First, it must be determined whether the model is a satisfactory representation of the industry. This is accomplished by testing the statistical relationship of each equation and by determining whether the estimated parameters of each equation conform to underlying theory. For instance, from economic theory, one would expect that the demand for a product is negatively related to its price. This implies that the parameter associated with price in the demand equation would be negative. Therefore, the regression calculation of this equation should yield a negative parameter coefficient for the price variable. The next test is whether the estimated coefficients and the equations are statistically significant. This is accomplished by means of standard statistical procedures which are applied to the estimated regression equations.

Once it is determined that the signs of the parameters conform to theory and the estimates of the parameters or coefficients are statistically significant, the model can then be used to undertake simulations. The endogenous variables can then be calculated for each successive year using the known values of the exogenous variables and the parameters or coefficients calculated by the regression analyses. Calculating these endogenous variables for successive years using the model equations and the estimated coefficients is called a simulation.

The validity of the model will be tested further by comparing the estimated or simulated values of the endogenous variables with actual historical values of these same variables. If the estimates of the endogenous variables coincide with, or "track", the actual values, we have an additional measure of confidence that the model is an accurate representation of the industry.

In order to determine how a new policy or a change in economic conditions might affect such things as output or employment, a shock is introduced into the model which represents a possible effect of the policy being considered and the simulation is repeated. In the present situation, the effects of increased pollution abatement expenditures by the pulp and paper industry are being studied. The basic effects are an increase in the cost of productive capacity that results from capital equipment purchases and an increase in variable production costs due to increased requirements for labour, energy, chemicals, etc.[6]

These effects are stimulated by multiplying the cost of capital and the cost of labour, materials, supplies and energy by simulation coefficients with preselected values. A value of one (1.00) implies that there is no cost increase.

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[6] Variable production costs are costs incurred only if the company engages in production. An example is the wage paid to production workers. Fixed costs, on the other hand, are costs incurred by the company even when there is no production, an example is the servicing costs of outstanding debts.

If the coefficient is set at 1.05, this indicates that capital and productions costs are increased by 5%. Likewise, a coefficient value of 1.10 implies a cost increase of 10%. Representation of increased capital costs was achieved by raising the cost of capital (i.e. the interest rate) so that the unit cost of new capacity is increased. In the model, this would be translated into an increase in the cost of producing a unit of output.

At the time that simulations were being undertaken, no estimates of the cost of the added pollution abatement in pulp and paper mills were available. Moreover, it was, and still is, difficult to estimate the dollar value of the possible cost increases. Consequently, cost increases of 1%, 5% and 10% were specified by setting the simulation coef- fients to 1.01, 1.05 and 1.1 and performing the following tests:

1) A control simulation without any shocks.
2) Ontario production costs increased by 1%.
3) Ontario production costs increased by 5%.
4) Ontario production costs increased by 10%.
5) 5% increase of production costs throughout Canada.
6) 5% increase of production costs throughout Canada and the United States.

The first test indicates whether the model is accurate in reproducing historical values and serves as a bench mark against which the results of subsequent simulation tests can be compared. Tests #2 through #6 define the cost increases which might be imposed on the industry by pollution abatement requirements under different conditions.

A policy of deliberately exempting Ontario mills from pollution abatement requirements was deemed impractical so that a simulation test that defined lower pollution abatement expenditures in Ontario than elsewhere was not explicitly run.

The data in Table 1 present the new capital investment undertaken in 1976 and 1977 as well as the values of labour, energy, supplies and materials used during 1975 and 1976. The dollar amounts that would be implied by a 1, 5 and 10% increase in these investment and operating costs are also indicated in Table 1.

The operating cost increases for Ontario mills were estimated as percentages of the total costs of labour, energy, supplies and materials. This probably overstates these costs because increases due to pollution abatement will be reflected primarily in energy and labour costs, not in the increased use of materials and supplies.

The simulated values of key endogenous variables without the additional abatement costs are then compared with calculated values of these variables from the simulations that have incorporated the added expenditures.

TABLE 1

"ORDERS OF MAGNITUDE" OF COST INCREASES
IN THE PULP AND PAPER INDUSTRY IN CANADA AND ONTARIO
WHICH WERE USED TO "SHOCK" THE SIMULATIONS

Investment[1] (Paper and Allied Industries)*

Year	Repair	New Capital	Total	Percentage of New Capital Investment 1%	5%	10%
		($ millions)				
Ontario						
1976	111.9	280.5	392.4	2.8	14.0	28.0
1977	134.9	237.8	372.7	2.4	11.9	23.8
Canada						
1976	498.1	688.7	1,186.8	6.9	34.4	68.9
1977	487.7	784.4	1,272.1	7.8	39.2	78.4

Expenditures on Labour, Energy, Supplies and Materials[2]
(Paper and Allied Industries)*

	Labour	Energy	Supplies	Total Expenses	Percentage of Total Expenses 1%	5%	10%
			($ million)				
Ontario							
1975	164.7	82.8	440.0	687.5	6.9	34.4	68.8
1976	237.7	131.3	579.4	948.4	9.5	47.4	94.8
Canada							
1975	754.9	398.7	2191.5	3345.1	33.5	167.2	334.5
1976	1,022.5	546.3	2,732.6	4,312.4	43.1	215.6	431.2

Sources: [1] Statistics Canada, Public and Private Investment - Outlook 1978, Catalogue #61-205, pp. 5, 22.

[2] Statistics Canada, Annual Census of Manufacturers, Pulp and Paper Mills, Catalogue #36-204, 1976, June 1976.

* Pulp and paper mills constitute about 90% of the total investment recorded for this sector.

REGRESSION AND SIMULATION RESULTS

There are nineteen "stochastic" equations in the model[7]. The parameters in these equations must be estimated by regression analysis. Seventeen other equations in the model are accounting identities for which no regressions need be run. Examples of identities are the two equations that measure total Canadian and Ontario output by summing the outputs in the various product categories.

For each regression there is a correlation coefficient measuring the "goodness of fit" or the degree to which the equation can explain changes in the dependent variable, such as price in the earlier example. The value of the correlation coefficient varies between 0 and 1. The average correlation coefficient for all 19 regressions is .9336. The lowest score is .7352 and the highest is .9996. This means that, on the average, the model can be used to explain 93% of the movements in variables that are determined within it. This figure is reassuringly high.

Correlation coefficients below .9 were obtained in the regressions of equations which determine Ontario employment (.735), Ontario woodpulp exports (.81) and Canadian output

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7 Stochastic equations refer to those equations which specify a random variable or "error term" to help explain changes in the dependent or "left hand side" (LHS) variable.

of residual products (.84). The estimates of these variables in simulation tests have, therefore, a greater potential for error than do equations with correlation coefficients of .9 or more. All the regression coefficients have the correct signs and the other statistical tests of the quality of the regressions are generally acceptable.

The results of the "control" simulation (Test #1) also appear to be reliable. Over the time period for which data were available (1958 to 1974), the average error or difference between the actual and the simulated values of variables determined by stochastic equations was 4.33%.[8] Five variables were tracked which had an average error that exceeded 5%:

1) Canadian industry consumption of materials, supplies and energy (5.90%)
2) Price of newsprint (5.33%)
3) Residual Canadian industry output (24.25%)
4) Ontario woodpulp exports (5.09%)
5) Canadian woodpulp exports (5.35%).

The average errors for the total industry outputs in Ontario and Canada were 2.64% and 2.90% respectively, a reasonably low error. Based on these results, it is concluded that the model can be usefully applied to policy analysis. The only caveat is that inferences should be made primarily on the basis of variables that do track well in the control simulation and that have good regression results.

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[8] This figure is the average root mean squared percentage error.

From these simulation results, a margin of error of about 5% in the simulation tests can be anticipated. The results of the simulations indicate how industry participants would have reacted to changing demand, rising costs, etc. over the test period of 1958-1974 assuming that industry participants behave in a rational manner. Note that the simulation results are the estimated annual values of output and employment that could have occurred over the test period as a result of the cost increase. They are not predictions of future output or employment changes. However, if we assume that industry participants will continue to react to future changes in costs in the same way as they have done in the past, these simulations provide an indication of the magnitude and the direction of future consequences of cost changes.

The simulation test values of key industry variables are plotted in Figures 1 to 10. Ontario producers are affected most when abatement costs rise in Ontario but not elsewhere. For example, over the test period, a cost increase of 1% results in a fall in total Ontario production by an average 2%, an 11% decrease in output results from a 5% cost increase, and a 22% Ontario production decrease is generated by a 10% cost increase (see Figure 5). The corresponding declines in employment depend on the assumption that is made about the extent to which extra labour will be required to operate pollution control facilities.

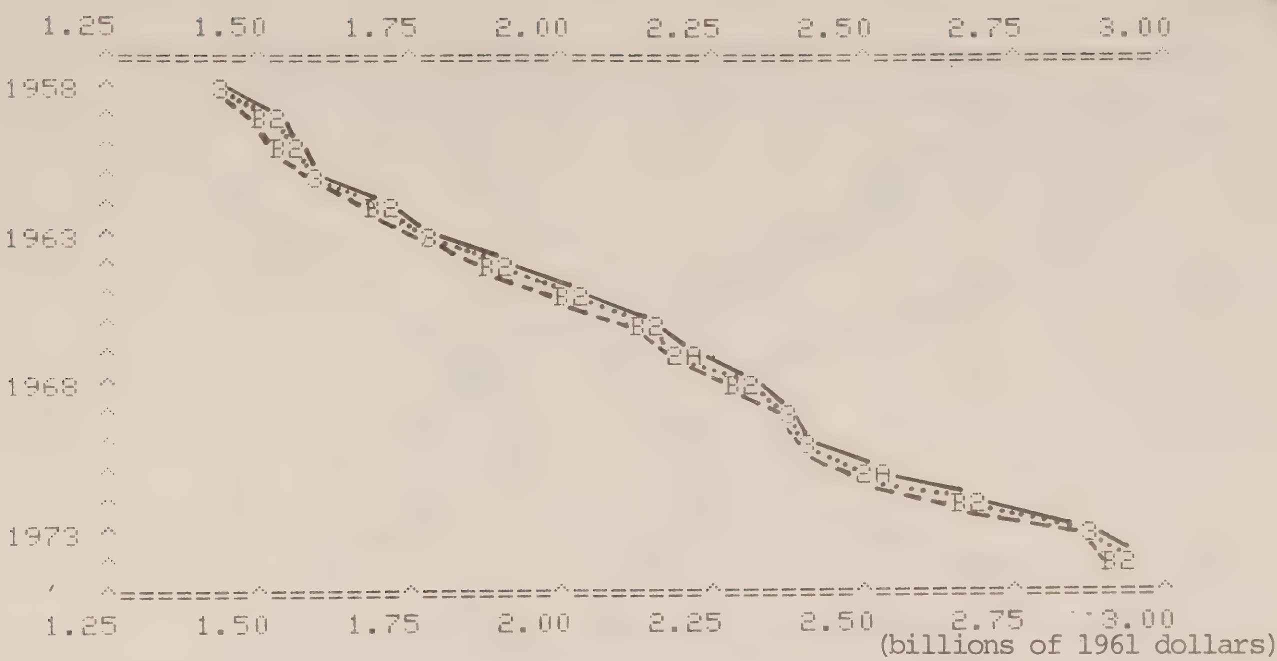


Figure 1: Simulated Values for Total Canadian Output

simulation test # 1	—A—	
" " # 5	--B--	
" " # 6	··C··	

Figure 2: Simulated Values for Output of Canadian Newsprint

simulation test # 1	—A—	
" " # 5	--B--	
" " # 6	··C··	

Figure 3: Simulated Values for Canadian Employment

simulation test # 1 —A—

" " # 5 ..B..

" " # 6 --C--

Figure 4: Simulated Values for Total Ontario Output (A)

simulation test # 1 —A—

" " # 5 ··B··

" " # 6 --C--

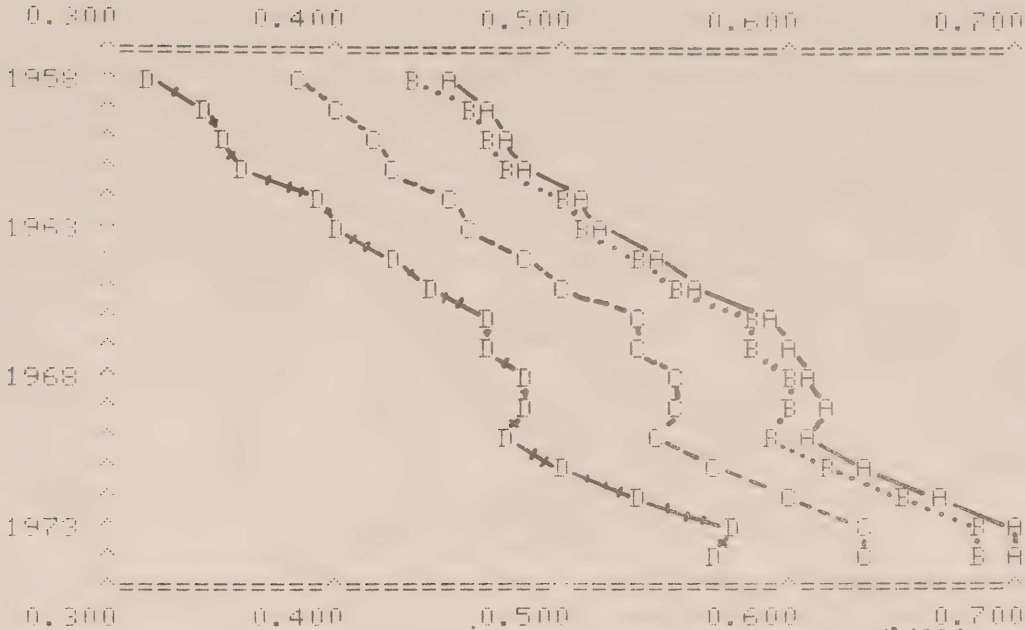


Figure 5: Simulated Values for Total Ontario Output (B)
simulation test # 1 ——A——
" " # 2 ··B··
" " # 3 --C--
" " # 4 ++D++

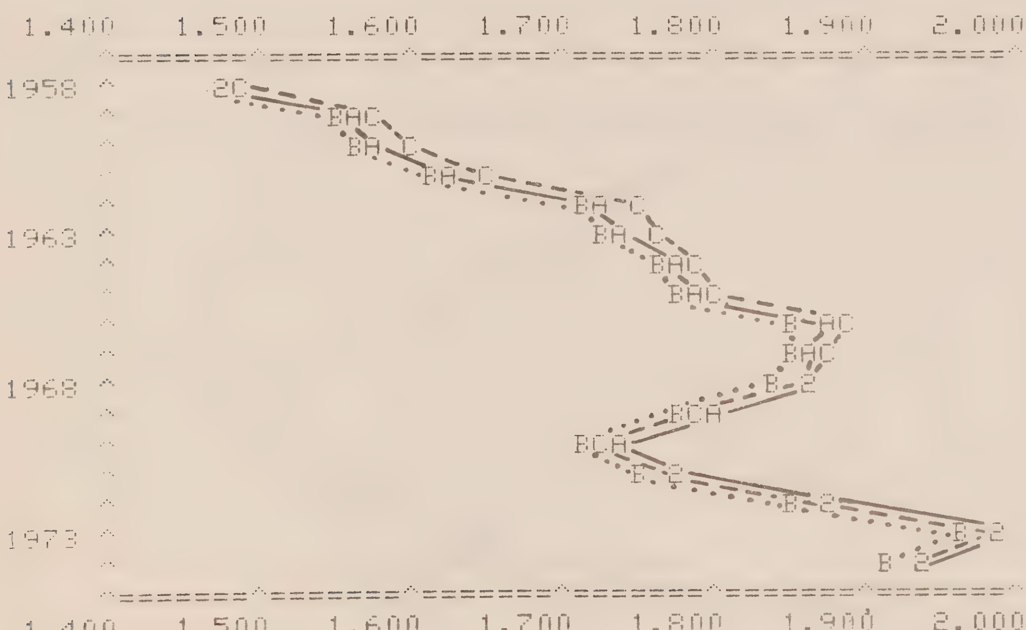


Figure 6: Simulated Values for Ontario Output of Newsprint (A)
simulation test # 1 ——A——
" " # 5 ··B··
" " # 6 --C--

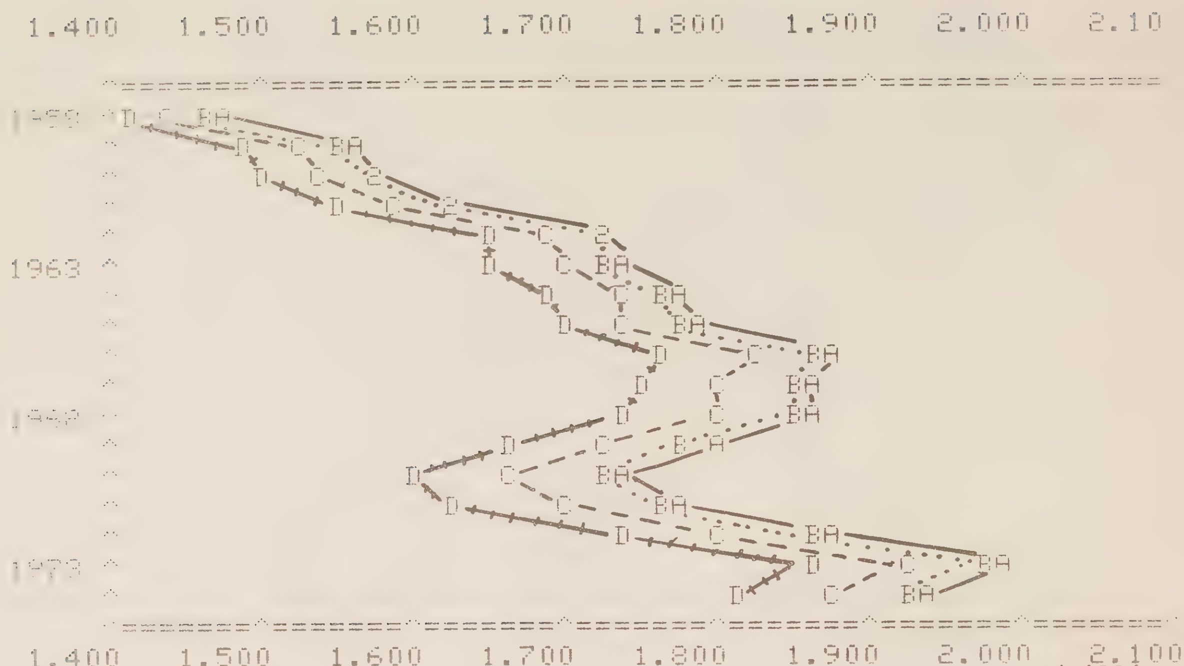


Figure 7: Simulated Values for Ontario Output of Newsprint (B)

simulation test # 1 ——A——
" " # 2 • • B • •
" " # 3 - - C - -
" " # 4 ++D++

Figure 8: Simulated Values for Ontario Employment (A)

simulation test # 1 ——A——
" " # 5 • • B • •
" " # 6 - - C - -

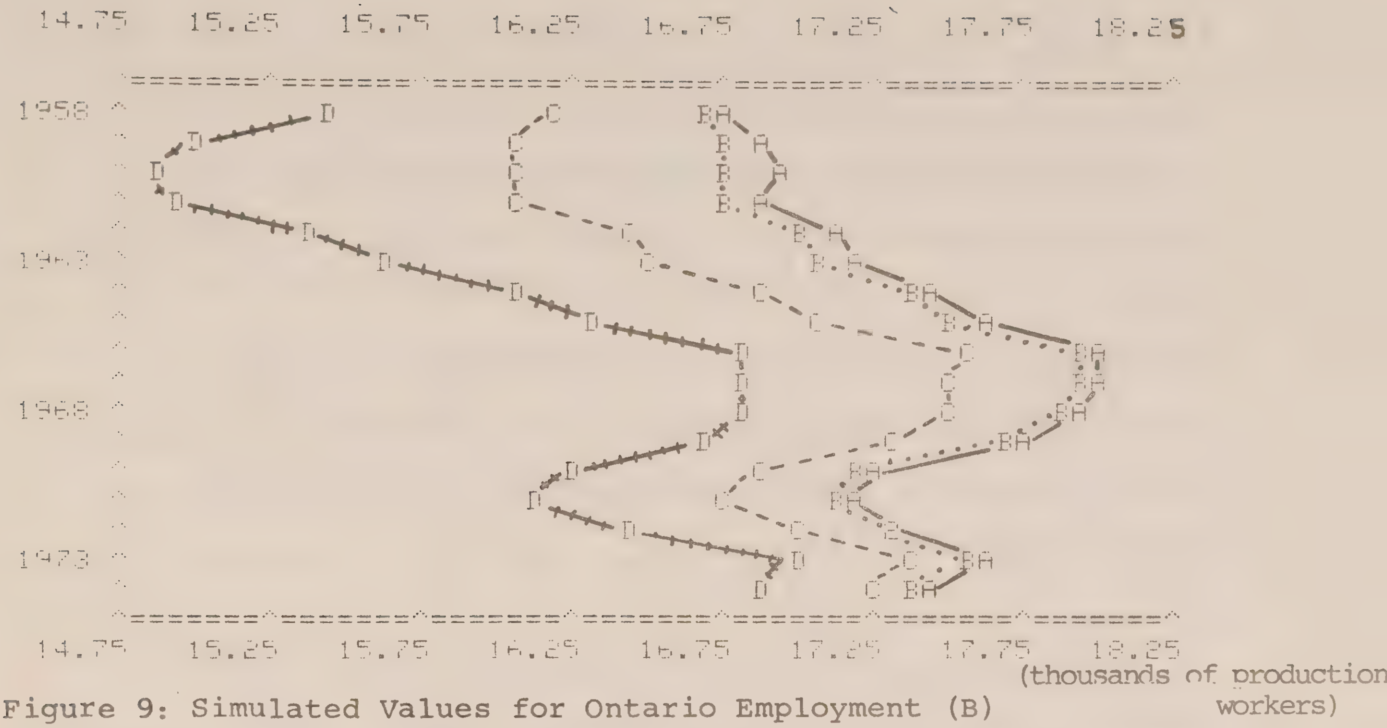


Figure 9: Simulated Values for Ontario Employment (B)

simulation test # 1 ——A——

" " # 2 ··B··

" " # 3 --C--

" " # 4 ++D++

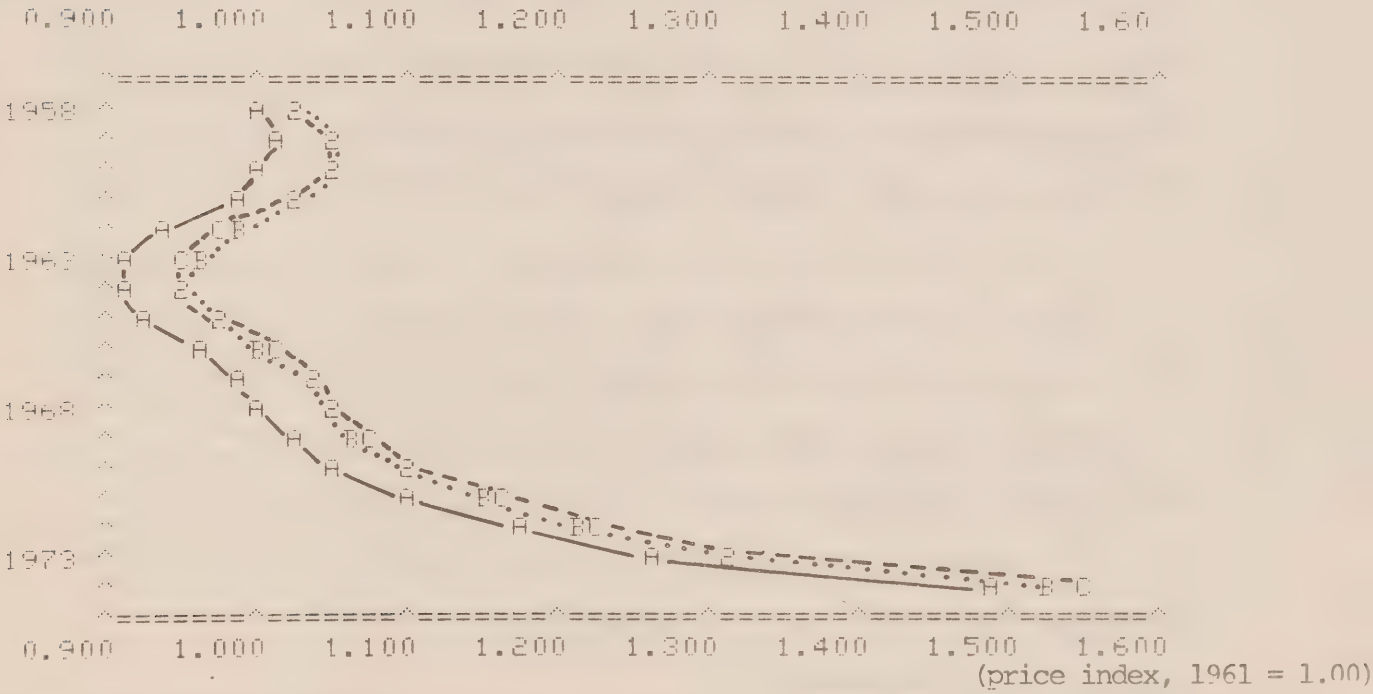


Figure 10: Simulated Values for the Price of Newsprint

simulation test # 1 ——A——

" " # 5 ··B··

" " # 6 --C--

Where it is explicitly assumed that employment would be increased in the industry by exactly the same percentages as the cost increases to undertake abatement activites, reductions in employment are not as large as those that occur for output. If it is assumed that no employment is generated by abatement activities (an extreme assumption), and Ontario mills *alone* bear cost increases of 5 or 10%, then the decline in market shares and employment over the study period is considerable.

However, in the more likely instance that abatement programs are undertaken by producers in other Canadian provinces and in the U.S. as well as Ontario, mills in Ontario would not suffer losses in sales or employment. From Figures 1 and 4, it can be seen that total Canadian and Ontario outputs do not change significantly. Production in Ontario increases slightly along with Canadian output. In both cases, the average percentage changes are under 1%.

At this time, there is not enough empirical information available to determine the extent to which employment would be increased by abatement activities. Even if abatement activities require *no* extra labour, the simulation results show that Ontario mills do not suffer a loss of jobs as long as producers in the rest of Canada or in the U.S. incur similar cost increases.

It should be noted that these employment effects are only first round effects and do not account for increased employment generated by the expenditures of the equipment manufacturing industry.

We can safely conclude, therefore, that as long as production and sales are not in some way curtailed by increased pollution abatement costs, pollution abatement will <u>not</u> result in any loss in employment.

In all of the simulation tests, the effect on capacity growth was very small. Under the worst conditions for Ontario, as expressed in test 4, Ontario newsprint capacity growth declined by only an average of 1% over the study period.

Based on the results from tests 5 and 6, increased costs will result in higher prices for all products. The average price rise for newsprint was about 4.5%, for woodpulp about 1.3%, and for other paper and board about 3.2%. Cost increases could not be passed on to produce prices in the woodpulp sector to the same extent that was possible in the newsprint sector. This reflects, to some extent, the fact that the woodpulp market is more competitive than the markets for newsprint and other paper and board products.

The results of this study reinforce Professor Muller's earlier conclusion that Canadian pulp and paper industry markets are not very sensitive to cost changes of the magnitude contemplated for pollution abatement (Muller, September 1975: pgs. 25-26). The effect on the Ontario industry depends crucially on whether abatement cost increases occur in the rest of Canada or the U.S. as well as within the borders of Ontario. When all producers face similar cost increases, Ontario producers are not likely to loose their market shares and may even improve their market position slightly. Moreover, if abatement cost increases are held below 9%, then the impact on output and employment in Ontario is likely to be small even if abatement cost increases are not experienced elsewhere.

The selected test results discussed above are summarized in Table 2 below. A more complete listing of these results may be found on Table III-3(A) on page 96.

TABLE 2

SELECTED RESULTS OF SIMULATION TESTS

THE IMPOSITION OF POLLUTION ABATEMENT COSTS ON THE ONTARIO PULP AND PAPER INDUSTRY

Average Percent Change in Ontario Variables 1958-1974*

Simulation Test	Total Ontario Shipments of Pulp & Paper (Value of Shipments of the Pulp & Paper Industry in Ontario (QGVRO)	Ontario Production of Newsprint (QNO)	Ontario Pulp and Paper Mill Production Workers (PWKO): Demand for labour equal to cost increases	Ontario Pulp and Paper Mill Production Workers (PWKO): No increase in the demand for labour
1. No shock	-	-	-	-
2. Ontario costs rise 1%	- 2.2	- .6	- .5	- 2.0
3. Ontario costs rise 5%	-11.2	-3.0	-3.0	-10.8
4. Ontario costs rise 10%	-22.4	-5.9	-7.4	-21.5
5. Ontario and Canadian costs rise 5%	.02	-0.01	8.5	- 0.2
6. Ontario, Canadian and U.S. costs rise 5%	.8	1.8	9.1	0.4

* Percentages are rounded to the nearest 0.1 percent.

Note: These percentages indicate the difference that would occur between simulations without pollution costs (Test 1) and simulations with pollution abatement costs.

Source of Results: Table III-3(A), page 96.

APPENDIX I

This appendix lists the symbols, equations, data, coefficients and parameters used in the model.

SYMBOL DEFINITIONS

ENDOGENOUS VARIABLES:

KNC
- Canadian newsprint capacity

KNO
- Newsprint capacity, Ontario

KNU
- U.S. newsprint capacity

KWC
- Canadian woodpulp capacity

MC
- Value of materials, supplies and energy used by the Canadian pulp and paper industry, deflated by a price index for materials, supplies and energy (PMX11)

MCO
- Value of materials, supplies and energy used by the Ontario pulp and paper industry, deflated by a price index for materials, supplies and energy (PMX11)

PNU
- Selling price index for American newsprint

PPC
- Industry selling price for other paper and board

PWC
- General wholesale price index for woodpulp

PWK
- Canadian pulp and paper mill production workers, '000's

PWKO
- Ontario pulp and paper mill production workers, '000's

QNC
- Production of newsprint in Canada in millions of tons

QNO
- Production of newsprint in Ontario in millions of tons

QNW
- North American newsprint production, millions of tons

QOTHER
- Residual production in the Canadian pulp and paper industry

QOTHERO
- Residual production in the Ontario pulp and paper industry (includes exports of woodpulp)

QWC
- Total wood pulp production, '000,000 tons from CPPA reference tables

QWO
- Ontario production of woodpulp, '000,000 tons

SPVR
- Canadian shipments of other paper and board deflated by the price index for other paper and board (PPC)

SPVRO
- Ontario shipments of other paper and paper board deflated by the price index for other paper and paper board (PPC)

XWVR
- Dollar value of wood pulp exports deflated by the general wholesale price index for wood pulp. Taken from CPPA reference tables

AMC, AMCO, ANC, ANCO
- Variable requirements needed to produce a unit of output

KNW
- North American output of newsprint

QGVR, QGVRO
- Value of shipments of the pulp and paper industry for Canada and Ontario respectively, deflated by the price index for pulp and paper mills

QNU
- U.S. production of newsprint in millions of tons

QNVR
- Value of Canadian newsprint shipments deflated by the newsprint price index (in effect, quantity multiplied by the 1961 price)

RXNC
- Measure of newsprint capacity utilization in Canada

R2, R3, R4, R5
- Cost variables derived for the capacity equations

UCAC, UCACO
- Total variable costs per unit of production for Canada and Ontario respectively.

EXOGENOUS VARIABLES:

ADJ
- Adjustment factor to reflect U.S. variable cost changes in the mid-fifties

AHEPP
- Average hourly earnings in pulp and paper mills

AHEPO
- Average hourly earnings in pulp and paper mills, Ontario

CC
- Canadian user cost of capital in paper and allied industries, defined using the implicit price deflator for capital stock in that industry (Stats. Canada)

CU
- U.S. user cost of capital defined using the price index for machinery and equipment (PKUS)

CIRCUS
- Circulation of national daily newspapers in the U.S.

EXCU
- Canadian dollar price of U.S. dollars

GNEC61
- Canadian G.N.E. in constant 1961 dollars

GNEU58
- U.S. G.N.E. in constant 1958 dollars

PMX11
- Implicit price index for materials and supplies purchased by the pulp and paper industry, 1961 1, constructed with data from Cat. 36-204.

PPU
- Price index for other paper and board, U.S.

PWU
- Wholesale woodpulp price index, U.S.

QGVROSM
- Smoothed trend of Ontario pulp and paper production derived by calculating the first order moving reference of the series

TIME
- Time trend, 1961 0.0

TPC
- Average tariff on paper and board products entering Canada

UCNUB
- Unit variable cost index for the production of newsprint in the U.S.

WPIC
- General wholesale price index, Canada, 1961 1.00

WPIU
- Wholesale price index, U.S.

PLPC
- Canadian price of imports of other paper and board

REGRESSION COEFFICIENTS:

K10	K100	K101	K102	K103	K104	K105	K106		
K11	K110	K111	K112	K113					
K12	K120	K121	K122	K123					
K13	K131	K132	K133	K140	K141	K142			
K60	K61	K62	K63	K71	K73	K81	K83	K90	K93
K94	K95	K96	N11	N12	N13	N20	N21	N40	N41
N42	N43	N50	N51	N53	N60	N62	N63	N64	N65
N66	N70	N71	N72	N73					

SIMULATION PARAMETERS:

Z1 Z2 Z3 Z4 Z5 Z6

EQUATIONS:

```
 1:   KNW == KNC+KNU

 2:   QNU == QNW-QNC

 3:   PLPC == PPU*(1+TPC)*EXCU/1.25615

 4:   QGVR == 0.120512*QNC+XWVR+SPVR+QOTHER

 5:   RXNC == 1.1*KNC/(1.1*KNC-QNC)

 6:   ANC == 0.627691-0.016823*TIME

 7:   AMC == 0.640157

 8:   UCAC == (0.439*AMC*PMX11+0.166*ANC*AHEPP/2.35)*Z1

 9:   LOG(QNW) = K10+K11*LOG(PNU/WPIU)+K12*LOG(GNEU58)+K13*LOG(
      CIRCUS)

10:   QNC/QNU = K20+K21*KNC/KNU+K22*UCAC/UCNUB*Z3+K23*DEL(1 :
      CIRCUS)

11:   PWK = K31*QGVR+K33*QGVR*TIME+K34*PWK(-1)

12:   DEL(1 : PNU) = K41*UCAC/EXCU*RXNC+K42*PNU(-1)*RXNC

13:   PPC = K51*UCAC+K52*PLPC+K53*PPC(-1)

14:   R2 == CC*EXCU/WPIU*Z2

15:   R3 == (UCNUB+ADJ)/WPIU*Z3

16:   R4 == CU/WPIU*Z4

17:   R5 == CC*EXCU/WPIU*Z5

18:   KWC = K60+K61*GNEU58(-2)+K62*R5(-2)+K63*KWC(-1)

19:   SPVR = K71*(PPC/WPIC)+K73*GNEC61

20:   MC = K81*QGVR+K83*MC(-1)

21:   KNC = K90+K93*R5(-2)+K94*KNC(-2)+K95*KNC(-1)+K96*CIRCUS(
      -2)

22:   KNU = K100+K101*CIRCUS(-2)+K103*UCAC(-2)/EXCU(-2)+K102*R3
      (-2)+K104*R4(-2)+K105*KNU(-2)+K106*KNU(-1)

23:   QNVR == 0.120512*QNC

24:   LOG(XWVR) = K110+K111*LOG(GNEU58)+K112*LOG(PWC/EXCU/WPIU)
      +K113*LOG(PWU/WPIU)

25:   QWC = K120+K121*SPVR+K122*XWVR+K123*QNVR
```

```
26:     DEL(1 : PWC) = K131*UCAC+K132*PWU*EXCU+K133*PWC(-1)

27:     QOTHER = K140+K141*SPVR+K142*QWC

28:     QGVRD == SPVRD+0.120512*QND+QOTHERD

29:     PWKD = N11*QGVRD+N12*QGVRD*TIME+N13*PWKD(-1)

30:     MCD = N21*QGVRD+N20

31:     ANCD == 2.11613-0.046617*TIME

32:     AMCD == 2.37814-0.152521/QGVRDSM

33:     UCACD == (0.515*AMCD*PMX11+0.173*ANCD*AHEPD/2.35)*Z6

34:     SPVRD = N40+N41*UCACD/WPIC+N42*PPC/WPIC+N43*GNEC61

35:     QND/QNU = N50+N51*UCACD/UCNUB*Z3+N52*KND/KNU+N53*DEL(1 :
        CIRCUS)

36:     KND = N60+N62*CIRCUS(-2)+N63*UCACD(-2)*EXCU(-2)/WPIU(-2)+
        N64*R2(-2)+N65*KND(-1)+N66*KND(-2)

37:     QOTHERD = N70+N71*UCACD/EXCU/WPIU+N72*UCAC/EXCU/WPIU+N73*
        GNEU58
```

DATA LISTINGS:

KNC - DATE REVISED: 11/09/76
ANNUAL DATA FROM 1947 TO 1975

CANADIAN NEWSPRINT CAPACITY (millions of tons)

1947	4.729	4.883	5.113
1950	5.227	5.34	5.51
1953	5.723	5.92	6.064
1956	6.243	6.756	7.239
1959	7.521	7.611	7.734
1962	7.844	8.055	8.274
1965	8.421	8.878	9.294
1968	9.655	9.857	10.059
1971	10.24	10.3	10.337
1974	10.038	10.2	

KNO - DATE REVISED: 12/03/76
ANNUAL DATA FROM 1947 TO 1974

NEWSPRINT CAPACITY, ONTARIO (millions of tons)

1947	1.111	1.153	1.172
1950	1.204	1.245	1.268
1953	1.279	1.338	1.375
1956	1.422	1.574	1.768
1959	1.905	1.917	1.915
1962	1.937	1.971	1.984
1965	1.94	2.025	2.103
1968	2.159	2.073	2.131
1971	2.161	2.161	2.139
1974	2.247		

KNU - DATE REVISED: 11/09/76
ANNUAL DATA FROM 1947 TO 1974

U.S.NEWSPRINT CAPACITY (millions of tons)

1947	0.845	0.85	0.876
1950	0.992	1.05	1.165
1953	1.17	1.28	1.409
1956	1.625	1.921	2.1
1959	2.39	2.399	2.376
1962	2.471	2.461	2.469
1965	2.372	2.545	2.844
1968	3.176	3.374	3.533
1971	3.642	3.694	3.819
1974	3.771		

KWC - DATE REVISED: 7/12/77
ANNUAL DATA FROM 1947 TO 1975

CANADIAN WOODPULP CAPACITY (millions of tons)

1947	0.	0.	8.9
1950	9.019	9.506	10.055
1953	10.136	10.542	10.83
1956	11.319	12.198	13.044
1959	13.074	13.185	13.602
1962	14.146	14.662	15.446
1965	16.215	17.488	18.981
1968	20.079	21.411	21.68
1971	22.844	22.62	23.608
1974	24.446	24.614	

MC - DATE REVISED: 8/16/77
ANNUAL DATA FROM 1956 TO 1974

VALUE OF MATERIALS, SUPPLIES AND ENERGY USED BY THE CANADIAN PULP AND PAPER INDUSTRY, DEFLATED BY A PRICE INDEX FOR MATERIALS, SUPPLIES AND ENERGY (PMX11). (billions of 1961 dollars)

1956	0.61046	0.597714	0.596469
1959	0.627686	0.674106	0.738886
1962	0.778226	0.80995	0.884144
1965	0.939078	1.02139	1.02877
1968	1.12493	1.22631	1.2265
1971	1.23081	1.30365	1.36813
1974	1.46661		

MO - DATE REVISED: 8/03/77
ANNUAL DATA FROM 1956 TO 1974

VALUE OF MATERIALS, SUPPLIES AND ENERGY USED BY THE ONTARIO PULP AND PAPER INDUSTRY, DEFLATED BY A PRICE INDEX FOR MATERIALS, SUPPLIES AND ENERGY (PMX11). (billions of 1961 dollars)

1956	0.208511	0.215499	0.227907
1959	0.232588	0.244541	0.248425
1962	0.260586	0.266334	0.278172
1965	0.278509	0.295401	0.298366
1968	0.315497	0.334643	0.34766
1971	0.336992	0.348607	0.365288
1974	0.392141		

PNW - DATE REVISED: 8/16/77
ANNUAL DATA FROM 1947 TO 1974

SELLING PRICE INDEX FOR AMERICAN
NEWSPRINT. (1961 = 1.00)

1947	0.659	0.725	0.75
1950	0.755	0.821	0.894
1953	0.932	0.933	0.935
1956	0.967	0.994	1.
1959	1.	1.	1.
1962	1.	1.	0.999
1965	0.984	1.014	1.041
1968	1.051	1.086	1.12
1971	1.168	1.214	1.272
1974	1.573		

PPC - DATE REVISED: 11/09/76
ANNUAL DATA FROM 1947 TO 1974

INDUSTRY SELLING PRICE INDEX FOR OTHER PAPER AND BOARD
(1961 = 1.00)

1947	0.	0.	0.
1950	0.	0.	0.
1953	0.	0.	0.
1956	0.936	0.961	0.972
1959	0.982	0.996	1.
1962	0.998	0.996	1.012
1965	1.016	1.05	1.082
1968	1.08	1.103	1.127
1971	1.148	1.174	1.286
1974	1.714		

PWC - DATE REVISED: 8/16/77
ANNUAL DATA FROM 1947 TO 1976

GENERAL WHOLESALE PRICE INDEX FOR
WOODPULP. (1961 = 1.00)

1947	0.998	1.029	0.941
1950	0.977	1.19	1.086
1953	0.985	0.959	1.004
1956	1.045	1.032	1.061
1959	1.051	1.043	1.
1962	1.029	1.017	1.052
1965	1.078	1.07	1.062
1968	1.051	1.072	1.17
1971	1.167	1.114	1.362
1974	2.154	2.85	2.663

PWK - DATE REVISED: 8/16/77
ANNUAL DATA FROM 1947 TO 1974

CANADIAN PULP AND PAPER MILL PRODUCTION
WORKERS, '000'S.

1947	42.315	43.9712	43.9178
1950	43.8644	47.9783	48.4058
1953	48.8866	51.2375	52.4129
1956	55.2446	54.55	52.5732
1959	53.428	53.3211	53.428
1962	53.7486	53.9623	56.42
1965	58.0762	60.8545	61.237
1968	60.296	62.307	62.025
1971	61.426	61.196	61.783
1974	66.584		

PWKO - DATE REVISED: 7/25/77
ANNUAL DATA FROM 1956 TO 1974

ONTARIO PULP AND PAPER MILL PRODUCTION WORKERS,
'000'S.

1956	16.835	16.976	16.551
1959	16.753	16.615	16.416
1962	16.358	16.609	17.162
1965	17.365	17.945	17.83
1968	17.537	17.936	17.832
1971	17.132	16.97	17.326
1974	17.753		

[illegible]NC - DATE REVISED: 8/16/77
ANNUAL DATA FROM 1947 TO 1974

PRODUCTION OF NEWSPRINT IN CANADA IN
MILLIONS OF TONS.

1947	4.474	4.64	5.187
1950	5.279	5.516	5.687
1953	5.721	5.984	6.191
1956	6.469	6.397	6.096
1959	6.394	6.739	6.735
1962	6.691	6.63	7.301
1965	7.72	8.419	8.051
1968	8.031	8.818	8.719
1971	8.455	8.82	9.14
1974	9.54		

ONO - DATE REVISED: 8/03/77
ANNUAL DATA FROM 1956 TO 1974

PRODUCTION OF NEWSPRINT IN ONTARIO IN MILLIONS OF TONS.

1956	1.47182	1.48744	1.459
1959	1.498	1.605	1.596
1962	1.60472	1.57017	1.70605
1965	1.74596	1.84511	1.81012
1968	1.76132	1.92339	1.85396
1971	1.76484	1.79502	1.95852
1974	1.99166		

ONW - DATE REVISED: 8/16/77
ANNUAL DATA FROM 1947 TO 1974

NORTH AMERICAN NEWSPRINT PRODUCTION,
MILLIONS OF TONS.

1947	5.3	5.507	6.087
1950	6.294	6.641	6.834
1953	6.805	7.195	7.743
1956	8.186	8.223	7.854
1959	8.358	8.777	8.829
1962	8.845	8.848	9.562
1965	9.965	10.902	10.76
1968	11.076	12.18	12.183
1971	11.931	12.456	12.818
1974	13.021		

OOTHER - DATE REVISED: 8/16/77
ANNUAL DATA FROM 1956 TO 1974

RESIDUAL PRODUCTION IN THE CANADIAN PULP AND PAPER
INDUSTRY. (billions of 1961 dollars)

1956	0.120404	0.082545	0.089702
1959	0.116909	0.129873	0.121562
1962	0.128325	0.130157	0.143618
1965	0.144233	0.138024	0.102687
1968	0.139744	0.113257	0.143775
1971	0.150086	0.246466	0.289307
1974	0.283152		

QOTHERO - DATE REVISED: 8/16/77
ANNUAL DATA FROM 1956 TO 1974

RESIDUAL PRODUCTION IN THE
ONTARIO PULP AND PAPER INDUSTRY (INCLUDES EXPORTS OF WOODPULP).
(billions of 1961 dollars)

1956	0.109197	0.109474	0.119462
1959	0.11747	0.125127	0.123205
1962	0.125659	0.129698	0.129838
1965	0.129652	0.143787	0.141593
1968	0.159792	0.171796	0.170931
1971	0.173775	0.192416	0.175896
1974	0.172566		

QWC - DATE REVISED: 7/12/77
ANNUAL DATA FROM 1950 TO 1974

TOTAL WOOD PULP PRODUCTION, ('000,000 TONS)

1950	8.473	9.315	8.968
1953	9.077	9.673	10.151
1956	10.734	10.425	10.137
1959	10.832	11.461	11.779
1962	12.133	12.474	13.742
1965	14.573	15.958	15.857
1968	16.762	18.59	18.308
1971	18.234	19.239	20.462
1974	21.518		

QWO - DATE REVISED: 7/25/77
ANNUAL DATA FROM 1956 TO 1974

ONTARIO PRODUCTION OF WOODPULP, ('000,000 TONS)

1956	2.73524	2.74618	2.73646
1959	2.851	2.967	2.981
1962	2.05239	3.07392	3.3178
1965	3.35675	3.58658	3.61877
1968	3.64404	3.96104	3.96907
1971	3.80014	3.93765	4.04436
1974	4.27421		

CPVR - DATE REVISED: 8/16/77
ANNUAL DATA FROM 1947 TO 1974

CANADIAN SHIPMENTS OF OTHER PAPER AND BOARD
DEFLATED BY THE PRICE INDEX FOR OTHER PAPER AND BOARD (PPC).

(billions of dollars, 1961 prices)

1947	0.	0.	0.
1950	0.	0.	0.
1953	0.	0.	0.
1956	0.308129	0.29767	0.309176
1959	0.32929	0.335743	0.352963
1962	0.372163	0.403249	0.426283
1965	0.454801	0.494731	0.503425
1968	0.517427	0.560689	0.57722
1971	0.582423	0.637152	0.709851
1974	0.822896		

SPVRO - DATE REVISED: 7/25/77
ANNUAL DATA FROM 1956 TO 1974

ONTARIO SHIPMENTS OF OTHER PAPER AND PAPER BOARD DEFLATED
BY THE PRICE INDEX FOR OTHER PAPER AND PAPER BOARD (PPC).

(billions of dollars, 1961 prices)

1956	0.165435	0.160024	0.152442
1959	0.157986	0.161266	0.16653
1962	0.174885	0.186747	0.196643
1965	0.202927	0.211011	0.209183
1968	0.218055	0.226591	0.231817
1971	0.234375	0.25001	0.288326
1974	0.320444		

XWVR - DATE REVISED: 7/12/77
ANNUAL DATA FROM 1950 TO 1974

DOLLAR VALUE OF WOOD PULP EXPORTS DEFLATED BY THE GENERAL
WHOLESALE PRICE INDEX FOR WOOD PULP. (billions of dollars, 1961 prices)

1950	0.213466	0.306834	0.26875
1953	0.252462	0.283022	0.29612
1956	0.291422	0.283339	0.269038
1959	0.296149	0.311718	0.346661
1962	0.359477	0.398517	0.438074
1965	0.457793	0.486044	0.511707
1968	0.597407	0.702882	0.671135
1971	0.683873	0.73369	0.777828
1974	0.865884		

ADJ - DATE REVISED: 8/16/77
ANNUAL DATA FROM 1947 TO 1975

ADJUSTMENT FACTOR TO REFLECT U.S.
VARIABLE COST CHANGES IN THE MID FIFTIES.

1947	0.	0.	0.
1950	0.	0.	0.
1953	-0.1338	-0.1346	-0.1409
1956	-0.1435	0.	0.
1959	0.	0.	0.
1962	0.	0.	0.
1965	0.	0.	0.
1968	0.	0.	0.
1971	0.	0.	0.
1974	0.	0.	

AHEPP - DATE REVISED: 11/09/76
ANNUAL DATA FROM 1947 TO 1975

AVERAGE HOURLY EARNINGS IN PULP AND PAPER MILLS. (dollars)

1947	0.94	1.07	1.14
1950	1.18	1.39	1.51
1953	1.63	1.72	1.79
1956	1.9	2.01	2.08
1959	2.15	2.24	2.35
1962	2.42	2.48	2.55
1965	2.65	2.92	3.11
1968	3.3	3.57	3.77
1971	4.22	4.56	4.87
1974	5.65	6.39	

AHEPO - DATE REVISED: 12/07/76
ANNUAL DATA FROM 1947 TO 1974

AVERAGE HOURLY EARNINGS IN PULP AND PAPER MILLS, ONTARIO. (dollars)

1947	0.94	1.07	1.14
1950	1.18	1.4	1.54
1953	1.66	1.75	1.83
1956	1.94	2.05	2.1
1959	2.16	2.25	2.35
1962	2.44	2.5	2.53
1965	2.61	2.86	3.05
1968	3.24	3.51	3.71
1971	4.12	4.43	4.79
1974	5.46		

CC - DATE REVISED: 8/16/77
ANNUAL DATA FROM 1951 TO 1975

CANADIAN USER COST OF CAPITAL IN PAPER
AND ALLIED INDUSTRIES, DEFINED USING THE IMPLICIT PRICE
DEFLATOR FOR CAPITAL STOCK IN THAT INDUSTRY. (percentage)

1951	2.47623	6.49862	8.88855
1954	9.63775	7.93089	6.81534
1957	8.84781	9.62878	10.9935
1960	10.7127	11.78	12.0973
1963	9.70724	8.91154	8.37866
1966	11.955	16.999	18.8559
1969	14.2742	13.9749	14.2799
1972	16.6222	12.7553	6.68939
1975	14.2329		

CU - DATE REVISED: 8/04/77
ANNUAL DATA FROM 1951 TO 1974

U.S. USER COST OF CAPITAL DEFINED
USING THE PRICE INDEX FOR MACHINERY AND EQUIPMENT. (percentage)

1951	0.884521	6.23999	7.2812
1954	7.21326	6.04941	3.35
1957	5.20847	8.24942	9.49848
1960	11.4016	11.64	11.47
1963	11.5086	10.0928	10.8119
1966	9.84517	10.4575	11.8222
1969	12.8336	13.2592	13.8747
1972	15.8828	15.2446	4.79386

CIRCUS - DATE REVISED: 8/16/77
ANNUAL DATA FROM 1947 TO 1976

CIRCULATION OF NATIONAL DAILY NEWSPAPERS (000,000's)
IN THE U.S.

1947	51.673	52.285	52.846
1950	53.829	54.018	53.951
1953	54.472	55.072	56.147
1956	57.102	57.805	57.418
1959	58.3	58.882	59.261
1962	59.849	58.905	60.412
1965	60.358	61.397	61.561
1968	62.023	62.06	62.108
1971	62.231	62.51	63.147
1974	61.877	60.655	60.977

EXCU - DATE REVISED: 12/10/76
ANNUAL DATA FROM 1947 TO 1975

CANADIAN DOLLAR PRICE OF U.S.DOLLARS

1947	1.002	1.002	1.031
1950	1.089	1.053	0.979
1953	0.983	0.973	0.986
1956	0.984	0.959	0.971
1959	0.959	0.97	1.013
1962	1.069	1.079	1.079
1965	1.078	1.077	1.079
1968	1.078	1.077	1.044
1971	1.01	0.991	1.
1974	0.978	1.017	

GNEC61 - DATE REVISED: 8/16/77
ANNUAL DATA FROM 1947 TO 1974

CANADIAN G.N.E. IN CONSTANT 1961 DOLLARS. (billions of 1961 dollars)

1947	21.366	21.898	22.735
1950	24.451	25.673	27.968
1953	29.408	29.047	31.788
1956	34.474	35.283	36.098
1959	37.47	38.553	39.646
1962	42.349	44.531	47.519
1965	50.685	54.207	56.016
1968	59.292	62.363	63.941
1971	67.782	71.515	76.345
1974	78.495		

GNEU58 - DATE REVISED: 8/16/77
ANNUAL DATA FROM 1947 TO 1974

U.S. G.N.E. IN CONSTANT 1958 DOLLARS. (trillions of 1958 dollars)

1947	0.3094	0.3222	0.3241
1950	0.3528	0.3809	0.3954
1953	0.4107	0.4054	0.4326
1956	0.4418	0.4499	0.4489
1959	0.476	0.4868	0.499
1962	0.5279	0.5488	0.5776
1965	0.6116	0.648	0.6657
1968	0.6948	0.7127	0.7104
1971	0.7316	0.7736	0.8147
1974	0.7998		

PMX11 - DATE REVISED: 6/30/77
ANNUAL DATA FROM 1956 TO 1974

IMPLICIT PRICE INDEX FOR MATERIALS AND SUPPLIES
PURCHASED BY THE PULP AND PAPER INDUSTRY. (1961 = 1.00)

1956	1.038	1.06	1.023
1959	1.019	1.002	1.
1962	0.989	0.989	1.011
1965	1.036	1.073	1.119
1968	1.112	1.131	1.137
1971	1.181	1.207	1.299
1974	1.634		

PPU - DATE REVISED: 11/24/76
ANNUAL DATA FROM 1947 TO 1974

PRICE INDEX FOR OTHER PAPER AND BOARD, U.S. (1961 = 1.00)

1947	0.7	0.749	0.735
1950	0.77	0.918	0.911
1953	0.905	0.915	0.938
1956	1.002	1.028	1.025
1959	1.029	1.036	1.
1962	1.001	1.	1.022
1965	1.033	1.055	1.059
1968	1.054	1.09	1.147
1971	1.166	1.2	1.277
1974	1.59		

PWU - DATE REVISED: 12/10/76
ANNUAL DATA FROM 1947 TO 1974

WHOLESALE WOODPULP PRICE INDEX, U.S. (1961 = 1.00)

1947	0.836	0.938	0.848
1950	0.836	1.	0.975
1953	0.954	0.96	0.988
1956	1.03	1.039	1.061
1959	1.061	1.055	1.
1962	0.981	0.966	1.012
1965	1.033	1.032	1.032
1968	1.032	1.032	1.131
1971	1.156	1.151	1.324
1974	2.248		

OGVPDSM - DATE REVISED: 8/16/77
ANNUAL DATA FROM 1956 TO 1974

SMOOTHED TREND OF ONTARIO PULP AND PAPER
PRODUCTION, DERIVED BY CALCULATING THE
FIRST ORDER MOVING AVERAGE OF THE SERIES. (billions of 1961 dollars)

1956	1.49955	1.48328	1.45903
1959	1.46644	1.49904	1.54064
1962	1.58246	1.63003	1.70637
1965	1.79566	1.90241	1.97551
1968	2.05551	2.17151	2.26835
1971	2.3343	2.43727	2.57331
1974	2.7444		

TIME - DATE REVISED: 11/09/76
ANNUAL DATA FROM 1947 TO 1975

TIME TREND, 1961 = 0.0

1947	-14.	-13.	-12.
1950	-11.	-10.	-9.
1953	-8.	-7.	-6.
1956	-5.	-4.	-3.
1959	-2.	-1.	0.
1962	1.	2.	3.
1965	4.	5.	6.
1968	7.	8.	9.
1971	10.	11.	12.
1974	13.	14.	

TPC - DATE REVISED: 11/24/76
ANNUAL DATA FROM 1947 TO 1974

AVERAGE TARIFF ON PAPER AND BOARD PRODUCTS ENTERING CANADA
(percentage)

1947	0.2418	0.2418	0.2418
1950	0.2418	0.2418	0.2418
1953	0.2418	0.2418	0.2418
1956	0.2418	0.2418	0.2418
1959	0.2418	0.2418	0.2418
1962	0.225	0.2083	0.2083
1965	0.2083	0.2083	0.2083
1968	0.1966	0.1646	0.15
1971	0.15	0.15	0.15
1974	0.15		

UCNUB - DATE REVISED: 8/16/77
ANNUAL DATA FROM 1947 TO 1974

UNIT VARIABLE COST INDEX FOR THE
PRODUCTION OF NEWSPRINT IN THE U.S.

1947	0.778	0.837	0.807
1950	0.853	0.92	0.898
1953	0.894	0.888	0.91
1956	0.921	0.74	0.734
1959	0.739	0.733	0.719
1962	0.709	0.706	0.701
1965	0.7	0.707	0.71
1968	0.732	0.756	0.76
1971	0.78	0.849	1.039
1974	1.269		

WPIC - DATE REVISED: 5/30/77
ANNUAL DATA FROM 1947 TO 1974

GENERAL WHOLESALE PRICE INDEX, CANADA. (1961 = 1.00)

1947	0.699957	0.828975	0.849978
1950	0.905272	1.02958	0.96871
1953	0.945992	0.930133	0.938277
1956	0.966995	0.974711	0.976425
1959	0.988427	0.989713	1.
1962	1.02872	1.04844	1.05186
1965	1.0733	1.1123	1.13202
1968	1.15688	1.21046	1.2276
1971	1.33005	1.61552	1.97728
1974	2.10587		

WPIU - DATE REVISED: 12/10/76
ANNUAL DATA FROM 1947 TO 1974

WHOLESALE PRICE INDEX, U.S. (1961 = 1.00)

1947	0.747	0.811	0.794
1950	0.823	0.908	0.887
1953	0.895	0.897	0.917
1956	0.958	0.984	0.987
1959	1.005	1.005	1.
1962	1.	0.999	1.004
1965	1.022	1.056	1.058
1968	1.084	1.127	1.168
1971	1.205	1.26	1.425
1974	1.694		

DATA SOURCES:

Canadian Pulp and Paper Association.	Reference Tables, Annual.
U.S., Dept. of Commerce.	Statistical Abstract of the United States (Washington, D.C.: U.S. Government Printing Office).
Muller, R.A.,	"A Simulation of Adjustment to Pollution Control Costs in the Pulp and Paper Industry", University of Toronto, Ph.D. thesis.
Statistics Canada	Cansim
Statistics Canada	Pulp and Paper Mills (Cat. #36-204)

PARAMETER AND COEFFICIENT LISTINGS:

Z1	1.
Z3	1.
Z5	1.
N35	121.02
N33	-104.116
N31	4.78759
K81	0.366711
K34	0.498373
K31	16.8228
K106	0.983352
N43	0.003043
N42	0.119319
K112	-0.193105
K110	0.176366
N40	0.053741
N72	2.88721
N70	-0.093341
K131	0.774248
K141	0.948667
K12	0.729821
K10	0.958201
K123	11.7749
K121	1.19209
K62	-0.016807
K60	-2.65194
K96	0.277533
K95	1.43316
K93	-0.009179
K120	-1.71974
K105	-0.37501
K102	-2.49832
K101	0.091961
N53	0.006451
K53	-0.803254
K51	2.80947
K73	0.00968
N50	0.226261
N65	0.605551
N63	-0.046417
N60	-1.46222
N21	0.591599
N12	-0.437212

Parameter and coefficient listings continued.

Z2	1.
Z4	1.
Z6	1.
N61	0.16721
N32	0.768731
K83	0.224724
K42	-0.110921
K33	-0.450886
K23	0.019276
K133	-1.18889
K41	0.280357
K113	0.492032
K111	1.84202
N41	-0.080202
N73	0.278026
N71	-0.671949
K132	0.880178
K142	-0.025153
K13	0.421452
K11	-0.129784
K22	-3.78136
K122	10.4589
K63	0.284158
K61	27.1214
K21	1.25317
K20	1.14286
K94	-0.852098
K90	-12.9333
K140	0.073901
K104	-0.036818
K103	1.45183
K100	-2.82598
N52	1.04315
K52	0.681616
N51	-0.138339
K71	-0.036085
N66	-0.243037
N64	-0.004944
N62	0.048167
N20	-0.040836
N13	0.432952
N11	19.7124

APPENDIX II

CHANGES MADE TO THE ORIGINAL MODEL

Changes that were made to the original model designed by R.A. Muller (1969) are described in this Appendix. Changes were made to both the data and to the specification of equations, these being discussed in turn. A full description of the original model is presented in Muller (1975; September 1975; 1976).

1. Changes in Data

Several data series were revised to incorporate the information from new or improved series published by Statistics Canada. All data are listed in Appendix I.

CC,CU: The formula used to estimate the user cost of capital is the same as that used by Muller (1975, pg. 193). A new price index of capital goods was obtained for both Canada and the U.S. The U.S. wholesale price index for machinery and equipment (1961 100) was used to define CU. To calculate CC, the index used was the price deflator for capital stock used by Statistics Canada for Paper and Allied industries.

PMX11: This price index replaces Muller's variable, PMX10. It is a current weighted index constructed using the formula:

$$PMX11_t = \sum_i P_{ti} Q_{ti} / \sum_i P_{1961,i} Q_{ti} \ , \quad \begin{array}{l} t = 1956, 1957 \ldots 1974 \\ i = 1, 2 \ldots 20 \end{array}$$

where

Q_i == purchased quantity of one of twenty inputs (i) used by the pulp and paper industry

P_i == price of the purchased input (i)

This index will understate the influence of observed changes in the input prices.

Intra-industry shipments of intermediate materials, supplies, and energy were not included in the measures of purchases. The necessary information was obtained from the Statistics Canada publication Pulp and Paper Mills (Cat. #36-204). Prices were approximated using the average annual unit cost, derived for each year by dividing total expenditure on each input by the purchased quantity.

The index measuring consumption of intermediate materials supplies and energy was re-estimated using PMX11 as a deflator. Intra-industry shipments of these products were netted out of the total dollar value of purchases before deflating.

QOTHER,QOTHERO: These two data series were added to the model. They are the residual shipments of the P & P industry for Canada and Ontario, respectively. The by-products of QOTHER are building board and by-products, while woodpulp exports make up most of QOTHERO. They were estimated as:[9]

QOTHER = = QGVR - XWVR - QNVR - SPVR

QOTHERO = = QGVRO - QNVRO - SPVRO

9 Double equality signs are used to designate an identity; single equality signs indicate a functional relation.

QGVR: This series is an index of physical shipments of products, constructed by deflating dollar values of total shipments by the output price index. A new price index was used to deflate the series - the industry selling price index for P & P mills. QGVRO is a similar index constructed by deflating Ontario shipments by the same index.

XWVR: This is an index for physical shipments of woodpulp exports. It was re-estimated using a different price deflator - the Canadian wholesale price index for woodpulp.

2. Specification and Estimation of the Model's Equations

The logical structure of the original model remains intact in the revised version used in this paper. A fixed coefficient production function is retained; demand functions and the market share functions are retained; and a similar fixed mark-up pricing mechanism is assumed. As in the original model, the present model is made dynamic by the imposition of a partial adjustment process in price setting and variable factor demand and by the use of a Koyck and a Pascal distributed lag structure for the demand for fixed capital.

Four significant structural changes were made:

a) variable factor supply was made exogeneous to the model;

b) the reduced form equation for woodpulp exports was replaced by separate pricing and demand equations;

c) the Ontario portion of the Canadian P & P industry was identified by the addition of 10 new equations;

d) the industry's residual output was estimated using an additional equation and an identity was used to estimate total industry output.

These changes will be dealt with in greater detail in the discussion of individual equations.

In order to make the Muller model usefl for an analysis of the effects on Ontario producers, Ontario sectorial equations had to be specified. This Ontario sector model is basically a replica of the Canadian model itself and the same general rationale underlies the specification of the sectorial equations. However, this current work must be taken only as a first approximation to the problem of modelling the Ontario industry. For example, the model does not fully account for competition between Ontario and other Canadian producers. Consequently, the findings relating to Ontario require cautious interpretation.

The model contains 17 identities and 20 stochastic equations. Stochastic equations were estimated using ordinary and generalized least squares regression techniques. An autoregressive correction was used where it

was capable of generating a necessary improvement in the Durbin-Watson statistic. The capital stock equations, however, were estimated using a correction for a 1st degree moving average error term. A Koyck transformation will produce this kind of error term.

The results of the regression analysis are discussed in the following sections on an equation by equation basis. The mneumonics used in the regressions reported below are those used in Troll printouts.[10] Their interpretation is as follows:

NOB	=	number of observations
NOVAR	=	number of variables
RSQ	=	coefficient of multiple correlation (R^2)
CRSQ	=	coefficient of multiple correlation corrected for degrees of freedom (R^2)
F	=	F - statistic
SER	=	standard error of the estimate
SSR	=	sum of squared residuals
DW(O)	=	Durbin-Watson statistic
GLS PARAMETERS	=	parameters generated by generalized least squares regressions
COEF	=	specification of variables subjected to GLS transformations
PARAMETERS	=	AUTO1 - 1st degree autoregressive correction AUTO2 - 2nd degree autoregressive correction MAV 1 - 1st degree moving average error term correction

----

[10] See the Troll Primer published by the National Bureau of Economic Research for information on the Troll computer program.

3. <u>Demand for Newsprint (QNW)</u>

The original variables were retained in this equation but it had to be estimated in Log form in order to secure the correct sign on the price variable. As in Muller's original work, the price variable is not significant but is retained for simulation purposes. The third explanatory variable, newspaper circulation, also has a low t-score. It was nevertheless, retained because it was shown to be a significant determinant in the newsprint capacity equations. The Durbin Watson statistic is significant at the 2% level (see equation 9-a).

The best alternative specification was one which used an index of total U.S. newspaper advertising expenditures in place of U.S. gross national expenditures. These results are shown for the Log form (equation 9-b). This specification provided superior t-scores but there is a deterioration of the sum of squared residuals (SSR) and the standard error of the regression estimates (SER). The resulting estimated price elasticity far exceeds our *a priori* expectations and causes simulated values of QNW to diverge from actual values. In addition, the correct deflator for advertising expenditures was not available and we were forced to use the U.S. general wholesale price index.

4. <u>Canadian and Ontario Shares of Newsprint Market (QNC/QNU, QNO/QNU)</u>

The original specification of this equation, used for the third regression shown below (equation 10-c), displayed

Equation # 9 - North American Demand for Newsprint

a) LOG(QNWD) = K10+K11*LOG(PNU/WPIU)+K12*LOG(GNEU58)+K13*LOG(CIRCUS)

```
NOB = 19        NOVAR = 4
RANGE =  1956 TO 1974
RSQ =    0.9416        CRSQ =    0.92992       F(3/15) =     80.613
SER =    0.0302        SSR = 1.365E-02         DW(0) =  1.71
```

GLS PARAMETERS

RHO1 0.4049

COEF	VALUE	ST ER	T-STAT
K10	0.95820	3.87650	0.24718
K11	-0.12978	0.42086	-0.30838
K12	0.72982	0.15497	4.70957
K13	0.42145	0.92890	0.45371

COEF	METHOD	PARAMETERS
ALL	GLS	AUTO1

b) LOG(QNWD) = K10+K11*LOG(PNU/WPIU)+K12*LOG(ADVERTIS/WPIU)+K13*LOG(CIRCUS)

```
NOB = 19        NOVAR = 4
RANGE =  1956 TO 1974
RSQ =    0.93964       CRSQ =    0.92757       F(3/15) =     77.838
SER =    0.0468        SSR = 3.279E-02         DW(0) =  1.72
```

COEF	VALUE	ST ER	T-STAT
K10	-14.03210	3.28119	-4.27652
K11	-1.38625	0.63401	-2.18648
K12	0.09624	0.22359	0.43041
K13	3.97725	0.80529	4.[illegible]

a persistent problem of serial correlation of the error terms. Since an autoregressive correction was of no avail, the problem seemed to stem from the specification. A linear version of Muller's second model of the market share equation was adopted (Muller, 1975, pg. 173-174). It was then postulated that American publishers, who make up the largest portion of the market, cut back on purchases from Canadian mills first when their own needs for newsprint fall. In effect, a portion of Canadian production accounts for the residual or volatile component of the market. This hypothesis was tested by adding the final explanatory variable, the change in newspaper circulation. The t-score of this variable was is not significant but the estimated coefficient does have the right sign and the serial correlation problem was resolved. Moreover, the other test statistics were markedly improved when this variable was added. An F-test was conducted to compare specifications in equations 10-a and 10-b; the result, F = 7.59, is significant at the 5% level. (Note that QNU = QNW - QNC).

The same model is used to explain the Ontario share of the North American newsprint market. These results are reported in equation 35.

5. <u>Demand for Woodpulp Exports (XWVR, QOTHERO)</u>

In his original work, Muller was forced to adopt a reduced form equation for the woodpulp export market. New data have permitted the specification of separate demand and

Equation # 10 - Canadian Share of the Newsprint Market

a) QNC/QNU = K20+K21*KNC/KNU+K22*UCAC/UCNUB*Z3+K23*DEL(1 : CIRCU)

NOB = 19 NOVAR = 4
RANGE = 1957 TO 1974
RSQ = 0.92734 CRSQ = 0.91177 F(3/14) = 59.561
SER = 0.1081 SSR = 0.164 DW(0) = 1.81

GLS PARAMETERS

RHO1 0.0795

COEF	VALUE	ST ER	T-STAT
K20	1.14286	0.52004	2.19762
K21	1.25317	0.10056	12.46260
K22	-3.78136	0.80183	-4.71592
K23	0.01928	0.03943	0.48889

COEF	METHOD	PARAMETERS
ALL	GLS	AUTO1

b) QNC/(QNW-QNC) = K20+K21*(KNC/KNU)+K22*(UCAC/UCNUB)

NOB = 19 NOVAR = 3
RANGE = 1956 TO 1974
RSQ = 0.71068 CRSQ = 0.67452 F(2/16) = 19.651
SER = 0.1243 SSR = 0.247 DW(0) = 1.51

GLS PARAMETERS

RHO1 0.6998

COEF	VALUE	ST ER	T-STAT
K20	0.54545	0.81872	0.66622
K21	0.93891	0.16877	5.56335
K22	-0.88421	0.88191	-1.00260

COEF	METHOD	PARAMETERS
ALL	GLS	AUTO1

c) QNC/QNW = K20+K21*(KNC/KNW)

```
NOB = 19       NOVAR = 2
RANGE =  1956 TO 1974
RSQ =    0.55861      CRSQ =    0.53264      F(1/17) =     21.514
SER = 8.52E-03        SSR = 1.233E-03        DW(0) =  1.22
```

GLS PARAMETERS

RHO1   0.7797

COEF	VALUE	ST ER	T-STAT
K20	-0.00293	0.16304	-0.01797
K21	0.99483	0.21450	4.63799

COEF	METHOD	PARAMETERS
ALL :	GLS	AUTO1

Equation # 35 - Ontario Share of the Newsprint Market

QNO/QNU = N50+N51*UCACO/UCNUB*Z3+N52*KNO/KNU+N53*DEL(1 : CIRCU)

```
NOB = 18       NOVAR = 4
RANGE =  1957 TO 1974
RSQ =    0.96968      CRSQ =    0.96318      F(3/14) =    149.225
SER =    0.0223       SSR = 6.980E-03        DW(0) =  1.93
```

COEF	VALUE	ST ER	T-STAT
N50	0.22626	0.10677	2.11910
N51	-0.13834	0.03943	-3.50891
N52	1.04315	0.05681	18.36170
N53	0.00645	0.00851	0.75782

supply equations. The demand equation used is one given by Muller in an appendix to his thesis (Muller, 1975, pg. 177). A second degree autoregressive correction was used for this regression and the resulting Durbin Watson statisic was significant at the 1% level. The two price variables are insignificant but were retained for simulation purposes. Because the demand equation is in Log form, elasticities can be read direclty from the regression parameters or coefficients. Therefore, the "own price" elasticity of wood pulp exports was -.19 and the cross price elasticity was .49. While demand is price inelastic, elasticity with respect to income appears to be quite high (see equation 24, pg. 57).

QOTHERO measures Ontario production of P & P products net of newsprint and other paper and paper board. This was used as a proxy measure of woodpulp exports from Ontario since it is comprised primarily of these. Data limitations required the use of a reduced form equation here. Demand was assumed to be a function of American national income, the Ontario price and the price of competing products. Observations were not available for the Ontario price of woodpulp. Fixed mark-up pricing was assumed and Ontario unit variable costs (UCACO) variable was entered into the demand equation in the place of Ontario price. Both the American and Canadian woodpulp prices were tried as competing prices, but neither had the correct sign. Since the Canadian woodpulp prices (PWC) are determined by a fixed mark-up pricing hypothesis, Canadian unit variable costs were used to

Equation # 24 - Demand for Canadian Woodpulp Exports

LOG(XWVR) = K110+K111*LOG(GNEU58)+K112*LOG(PWC/EXCU/WPIU)+K113*LOG(PWU/WPIU)

NOB = 19 NOVAR = 4
RANGE = 1956 TO 1974
RSQ = 0.97491 CRSQ = 0.9699 F(3/15) = 194.314
SER = 0.0462 SSR = 3.201E-02 DW(0) = 2.26

GLS PARAMETERS

RHO1 0.7805
RHO2 -0.4963

COEF	VALUE	ST ER	T-STAT
K110	0.17637	0.04989	3.53517
K111	1.84202	0.08747	21.05920
K112	-0.19310	0.48857	-0.39525
K113	0.49203	0.47549	1.03479

COEF	METHOD	PARAMETERS
ALL	GLS	AUTO2

Equation # 37 - Demand for Ontario Woodpulp Exports

QOTHERO = N70+N71*UCACO/EXCU/WPIU+N72*UCAC/EXCU/WPIU+N73*GNEU58

NOB = 19 NOVAR = 4
RANGE = 1956 TO 1974
RSQ = 0.84431 CRSQ = 0.81318 F(3/15) = 27.116
SER = 7.31E-03 SSR = 8.025E-04 DW(0) = 2.03

GLS PARAMETERS

RHO1 0.4275

COEF	VALUE	ST ER	T-STAT
N70	-0.09334	0.07564	-1.23409
N71	-0.67195	0.50108	-1.34101
N72	2.88721	2.05689	1.40368
N73	0.27803	0.06121	4.54195

COEF	METHOD	PARAMETERS
ALL	GLS	AUTO1

represent prices of competing products. The estimated parameters had the correct sign but neither price variable was significant. Nevertheless, each was retained for simulation.

Price elasticities could not be estimated for two reasons. First the reduced form equation is underidentified. Moreover, the use of the Canadian price rather than the price set by producers outside of Ontario, means that this price is, in part, based on the Ontario price. This distortion suggests that both price coefficients will be biased.

Although the Ontario equation leaves much to be desired, it must stand as given in light of data constraints.

6. <u>Demand for Other Paper and Paper Board (SPVR, SPVRO)</u>

Muller's specification has been adopted here with the exception that the price of competing products was dropped because it had the wrong sign. The price elasticity of demand at the mean is -.07 and the income elasticity of demand at the mean is 1.07 (see equation 19).

We are again forced to use a reduced form equation to describe the Ontario market. The derivation of this equation is analogous to that of the equation for QOTHERO. In this case, the Canadian price index for other paper and paper board had the correct sign and it was not necessary to

Equation # 19 - Demand for Canadian Paper and Paperboard

SPVR = K61*(PPC/WPIC)+K63*GNEC61

```
NOB = 19        NOVAR = 2
RANGE =  1956 TO 1974
RSQ =    0.96628      CRSQ =    0.9643       F(1/17)  =    487.151
SER =    0.0226       SSR = 8.713E-03        DW(0)  =  1.77
```

GLS PARAMETERS

```
RHO1     1.0277
RHO2    -1.0000
```

COEF	VALUE	ST ER	T-STAT
K61	-0.03609	0.02048	-1.76211
K63	0.00968	3.57651E-04	27.06640

COEF	METHOD	PARAMETERS
ALL	GLS	AUTO2

Equation # 34 - Demand for Ontario Paper and Paperboard

SPVRO = N40+N41*UCACO/WPIC+N42*PPC/WPIC+N43*GNEC61

```
NOB = 19        NOVAR = 4
RANGE =  1956 TO 1974
RSQ =    0.94518      CRSQ =    0.93422      F(3/15)  =     86.212
SER = 5.98E-03        SSR = 5.355E-04        DW(0)  =  1.97
```

GLS PARAMETERS

```
RHO1     1.3879
RHO2    -1.0000
```

COEF	VALUE	ST ER	T-STAT
N40	0.05374	0.04909	1.09471
N41	-0.08020	0.05951	-1.34776
N42	0.11932	0.08056	1.48111
N43	0.00304	2.36225E-04	12.88330

COEF	METHOD	PARAMETERS
ALL	GLS	AUTO2

resort to variable unit costs. The income elasticity of demand at the mean was .75 (see equation 34).

7. Product Prices (PNU, PWC, PPC)

Product prices were estimated using the same equations developed by Muller. The regression results are reported on pages 66 and 67.

An additional equation was added for the price of woodpulp to complete the woodpulp sector of the model. For this equation, the American woodpulp price adjusted for the exchange rate is the limit price.

The general form of these equations is given as:

$$P_t = ab(1-c)(UCAC) + ac(PL_t) \; a(P_{t-1})$$

where: a = speed of adustment parameter

b = long run cost parameter

c = long run limit price parameter

PL = limit price (price of competing goods)

Note that in the equation for PPC, the third coefficient is (1-a) since PPC is not given in difference form.

Table II-1 below reports the values of the structural parameters as estimated and lists both the mean long-run cost and the limit price elasticities. The limit price elasticities are labelled (e-UCAL, e-PL), respectively in the table.

TABLE II-1
DEMAND PARAMETERS AND ELASTICITIES

	PPC	PNU	PWC
Structural Parameters and Elasticities	Selling Price Index for Other Paper and Board	Selling Price Index for U.S. Newsprint	Wholesale Price Index for Wood Pulp
a	1.80	.57	1.19
c	.38	-	.74
b	2.50	2.53	2.51
e-UCAC	.98	1.0020	.94
e-PL	1.77	-	1.20

The adjustment parameter for PNU is derived by multiplying the regression coefficient by the mean value of RXNC.

Although the price equations yielded reasonable values for the structural parameters in Muller's original work, it is evident that there is something amiss with the specification or with the regression techniques now because the parameter values given in Table II-1 are not consistent with theory. The cost parameter implies that variable costs constitute 40% of revenue while in fact they are about 60% of revenue. The limit price elasticities are high and the adjustment parameters for PPC and PWC exceed unity. These equations obviously require further work, but they were used as provided for current simulations. It is not expected that any resulting errors in the simulations are serious. If anything, the model will overestimate price changes because of the high adjustment coefficient. This will exaggerate the

Equation # 12 - Price of Newsprint

```
DEL(1 : PNU) = K41*UCAC/EXCU*RXNC+K42*PNU(-1)*RXNC

NOB = 18       NOVAR = 2
RANGE =  1957 TO 1974
RSQ =    0.93823      CRSQ =    0.93437      F(1/16) =    243.020
SER =    0.0155       SSR = 3.851E-03        DW(0) =  2.08

GLS PARAMETERS

RHO1     0.9369

COEF              VALUE           ST ER          T-STAT

K41             0.28036         0.02386        11.75140
K42            -0.11092         0.01194        -9.28653

COEF     METHOD     PARAMETERS

ALL       GLS        AUTO1
```

Equation # 13 - Price of Paper and Paperboard

```
PPC = K51*UCAC+K52*PLPC+K53*PPC(-1)

NOB = 18       NOVAR = 3
RANGE =  1957 TO 1974
RSQ =    0.96923      CRSQ =    0.96513      F(2/15) =    236.279
SER =    0.0230       SSR = 7.956E-03        DW(0) =   1.77

GLS PARAMETERS

RHO1     0.7314

COEF              VALUE           ST ER          T-STAT

K51             2.80947         0.42232         6.65242
K52             0.68162         0.20900         3.26138
K53            -0.80325         0.14860        -5.40552

COEF     METHOD     PARAMETERS

ALL       GLS        AUTO1
```

Equation # 26 - Price of Woodpulp

DEL(1 : PWO) = K131*UCAC+K132*PWU*EXCU+K133*PWO(-1)

```
NOB = 18        NOVAR = 3
RANGE =  1957 TO 1974
RSQ =    0.98021      CRSQ =    0.97758       F(2/15) =    371.548
SER =    0.0240       SSR = 8.620E-03         DW(0) =  2.10
```

GLS PARAMETERS

RHO1 0.8148

COEF	VALUE	ST ER	T-STAT
K131	0.77425	0.41549	1.86347
K132	0.88018	0.04570	19.26120
K133	-1.18889	0.14316	-8.30463

COEF	METHOD	PARAMETERS
ALL	GLS	AUTO1

response to unit variable cost increases and result in an exaggerated response to pollution abatement costs. The true response should, therefore, be less than the simulated one.

8. Industry Output (QGVR, QGVRO)

In Muller's model, industry output is determined in a stochastic equation with the summation of the outputs of newsprint, exported woodpulp and other paper and paper board as the independent variable. This equation is meant to represent an identity but is used because the industry's residual product (about 5% of sales) is not explained in the model. This is not an unreasonable procedure since much of this residual (QOTHER) is comprised of byproducts and services both of which would be closely correlated with principal outputs.

It was decided to reinstate the identity status of the function describing total output by adding an equation explaining production of residual output. The main obstacle to this course of action is that there are no observed prices for this residual component. The wholesale price index was, therefore, used as a proxy and the following ad hoc reduced form specification was tested:

QOTHER = f (SPVR, QWC, GNEC61, WP1C)

A priori, the most important RHS variables in this specification are SPVR and QWC since these are less highly

aggregated than the others and, in all probability, more closely related to the production of by-products. For the purpose of simulation tests, these variables will establish an interdependency between QOTHER and the rest of the model.

Two restricted regressions were made by excluding WP1C and then both WP1C and GNEC61. The regression results are reported in equations 27(a), (b) and (c) below and F tests of the restricted regressions were as follows:

$$F_{ab} = 13.2691$$
$$F_{ac} = 7.9298$$
$$F_{bc} = .9089$$

The unrestricted form (F_{ab}) clearly has a closer fit than the other two. However, only one of the variables, WP1C, is significant. Moreover, it does not allow QOTHER to move in the same direction as other industry outputs as these outputs grow. This specification was accordingly rejected. Between specifications b and c there was little to choose as is witnessed by the relavent F-scores. The simpler specification was chosen for the model. The implication of this is that neither supply or demand are price or income sensitive.

The measure of residual output for Ontario (QOTHERO) contained largely woodpulp exports and was used as a proxy for this variable. The equation for this variable is described in the section on woodpulp exports. Total industry output for Ontario is given as an identity.

Equation #27 - Residual Output of Canadian Producers

a) QOTHER = K140+K141*SPVR+K142*OWC+K143*GNEC61+K144*WPIC

NOB = 19 NOVAR = 5
RANGE = 1956 TO 1974
RSQ = 0.88163 CRSQ = 0.84781 F(4/14) = 26.068
SER = 0.0208 SSR = 6.053E-03 DW(0) = 2.00

GLS PARAMETERS

RHO1 0.1394

COEF	VALUE	ST ER	T-STAT
K140	-0.06258	0.04909	-1.27486
K141	-0.20465	0.32359	-0.63243
K142	-4.62437E-04	0.01472	-0.03142
K143	0.00116	0.00340	0.34186
K144	0.20976	0.05806	3.61302

COEF	METHOD	PARAMETERS
ALL	GLS	AUTO1

b) QOTHER = M30+M31*SPVR+M32*OWC+M33*GNEC61

NOB = 19 NOVAR = 4
RANGE = 1956 TO 1974
RSQ = 0.81149 CRSQ = 0.77379 F(3/15) = 21.524
SER = 0.0280 SSR = 1.179E-02 DW(0) = 1.78

COEF	VALUE	ST ER	T-STAT
M30	0.08464	0.03760	2.25120
M31	0.79188	0.25824	3.06647
M32	-0.02907	0.01465	-2.66712
M33	0.00517	0.00433	1.19376

c) QOTHER = K140+K141*SPVR+K142*OWC

NOB = 19 NOVAR = 3
RANGE = 1956 TO 1974
RSQ = 0.79359 CRSQ = 0.76778 F(2/16) = 30.757
SER = 0.0284 SSR = 1.291E-02 DW(0) = 1.64

COEF	VALUE	ST ER	T-STAT
K140	0.07390	0.03699	1.99796
K141	0.94867	0.22528	4.21114
K142	-0.02515	0.00899	-2.79897

9. <u>Variable Factor Prices</u> (AHEPP, AHEPPO, PMX11)

The two equations that explain factor prices described the supply side of the factor market in Muller's model. The underlying structure is a disequilibrium model with prices adjusting gradually in response to excess demand.

Using new data, it was not possible to get a regression that had correct signs on the coefficients as well as a good fit. The specification calls for a measure of demand, but the available data measure only market transactions. These transactions represent actual demand as long as there is no excess demand. An additional problem may arise from the level of aggregation of the price index for energy, materials and supplies. Twenty commodity prices are used to construct this index. Some of these commodities are specific to the P & P industry while others are widely used industrial commodities. The attempt to treat several distinct markets as a single market may have not contributed to the problems encountered with this equation.

For these reasons, factor prices have been treated as exogenous variables in the present model. This is obviously a poor compromise since certain factor prices will be affected by industry activity. If a positive relationship between industry activity and factor prices is anticipated, as the excess demand hypothesis would suggest, then the omission of this interaction will tend to exaggerate the

negative impact of pollution abatement costs by not allowing the output reductions to dampen upward movements in factor prices. At some future date, it would be useful to study these interactions more carefully in order to account for the collective bargaining process in the labour market and disaggregate markets for various energy and material inputs. Incorporation of these factors would likely increase the accuracy of the model and make it a more flexible tool for various policy studies.

10. Variable Factor Demand (PWK, PWKO, MC, MCO)

The assumption of fixed technical coefficients was retained for these equations. The demand for labour equations yielded the best results without the squared value of output on the right hand side of the equation. The demand for materials, supplies, and energy equations worked best with a single variable in output. For the Ontario equation, the lagged dependent variable was dropped in favour of an intercept. The regression results are reported on pages 73 and 74.

Our calculation of AMC, AMCO, ANC and ANCO, the normal unit factor requirements, is analogous to Muller's calculation. Likewise, the definitions of UCAC and UCACO, the indices of unit variable factor costs, are derived with this formula. For the definition of UCACO, a measure of Ontario pulp and paper industry wage rates was available, but PMX11, the national price index, was used for the cost

Equation # 11 - Employment by Canadian Producers

PWK = K31*QGVR+K33*QGVR*TIME+K34*PWK(-1)

NOB = 18 NOVAR = 3
RANGE = 1957 TO 1974
RSQ = 0.96344 CRSQ = 0.95857 F(2/15) = 197.653
SER = 0.8692 SSR = 11.332 DW(0) = 1.91

COEF	VALUE	ST ER	T-STAT
K31	16.82280	2.89376	5.81348
K33	-0.45089	0.08702	-5.18140
K34	0.49837	0.08659	5.75524

Equation # 29 - Employment by Ontario Producers

PWKO = N11*QGVRO+N12*QGVRO*TIME+N13*PWKO(-1)

NOB = 18 NOVAR = 3
RANGE = 1957 TO 1974
RSQ = 0.76633 CRSQ = 0.73518 F(2/15) = 24.597
SER = 0.2064 SSR = 0.639 DW(0) = 2.05

RHO PARAMETERS

RHO1 0.4095

COEF	VALUE	ST ER	T-STAT
N11	19.71240	3.30221	5.96945
N12	-0.43721	0.07974	-5.48320
N13	0.43295	0.09515	4.55002

COEF	METHOD	PARAMETERS
ALL	GLS	AUTO1

Equation # 20 - Purchase of Materials, etc. by Canadian Producers

MC = K81*OGVR+K83*MC(-1)

```
NOB = 18        NOVAR = 2
RANGE =  1957 TO 1974
RSQ =    0.91626       CRSQ =    0.91103       F(1/16) =    175.067
SER =    0.0194        SSR = 6.012E-03         DW(0) =  1.60
```

GLS PARAMETERS

RHO1 0.9767

COEF	VALUE	ST ER	T-STAT
K81	0.36671	0.04265	8.59908
K83	0.22472	0.09921	2.26513

COEF	METHOD	PARAMETERS
ALL	GLS	AUTO1

Equation # 30 - Purchase of Materials, etc. by Ontario Producers

MCO = N21*OGVRO+N20

```
NOB = 19        NOVAR = 2
RANGE =  1956 TO 1974
RSQ =    0.93372       CRSQ =    0.92982       F(1/17) =    239.471
SER = 7.12E-03         SSR = 8.622E-04         DW(0) =  1.67
```

GLS PARAMETERS

RHO1 0.6[illegible]

COEF	VALUE	ST ER	T-STAT
N21	0.59160	0.03823	15.47480
N20	-0.04084	0.02183	-1.87086

COEF	METHOD	PARAMETERS
ALL	GLS	AUTO1

of MCO. The only foreseeable improvement that can be made on this use of PMX11 is the adjustment of the pulpwood costs component of the index since this data may be available for Ontario.

11. Capacity Equations (KNU, KNC, KWC, KNO)

The demand equations for capacity incorporated a fixed technical coefficient production function as per Muller's original specification. The underlying structure of his final specification is a dynamic profit optimization model in the tradition of Jorgenson's work.

In the present regressions for Canadian capacity in newsprint and woodpulp, considerable difficulty was encountered in securing the expected signs on the cost variables. Both should have been negative, but usually one or the other came out positive. The problem may have arisen because of the measure of capital that is used, being the reported capacity measured in potential physical output of paper or pulp. As such, this is not a direct measure of capital stock and the precise relationship between capital stock and capacity has not been modelled. The relationship between capacity and cost is, therefore, not clearly known.

To investigate the possibility that this is the source of our difficulties, the Statistics Canada constant dollar measure of P & P capital stock was substituted for capacity in the capacity equations. The perversity in the signs on

the cost variables persisted. An alternative explanation of the difficulty is that, in the annual data used, the time trends dominate the independent variation of costs and capacity. Too much information is lost in the annualization of data to allow our statistical tools to identify the underlying relationship. Unfortunately, quarterly data isn't available to explore this possibility. Finally, the structure itself may be in error because no substitution between capital and labour is permitted with fixed technical coefficients in production. It may be that the positive sign on variable costs is pointing to an actual substitution effect. This possibility was not explored at this time since it would constitute a major restructuring of the model. In the end, the drastic measure of dropping variable factor costs from these two equations was adopted. Though this step has no econometric or economic justification, it is expedient and must stand for the time being. The other two capacity equations performed adequately with the original specifications. Some variables were insignificant but were retained for simulation purposes.

The omission of variable factor costs from the two capacity equations may result in an underestimation of the response of new investments to rising pollution abatement costs. This will in turn be reflected in an overestimate of the output of Canadian newsprint. This aspect of the model warrants further investigation and testing with new data.

Long-run capital stock elasticities at the mean with respect to variable and capital costs, are given in Table II-2.

TABLE II-2

CAPITAL STOCK ELASTICITIES

Type of Elasticity	KNU U.S. Newsprint Capacity	KNC Canadian Newsprint Capacity	KNO Ontario Newsprint Capacity	KWC Canadian Woodpulp Capacity
Own variable costs	-1.54	-	- .06	-
Own capital costs	- .32	- .03	- .04	- .02
Canadian variable costs	.51	-	-	-

The Canadian capital stock elasticities are low and suggest that cost variations are not an important factor in investment decisions (Muller, 1975, pg. 113). The disparity between American and Canadian capacity elasticities is suspicious and calls for further investigation. If American investments are not actually as sensitive as indicated by these regressions, then simulation tests that have pollution abatement costs applied across North America will generate results biased in Canada's favour.

Equation # 21 - Canadian Newsprint Capacity

KNC = K90+K93*P5(-2)+K94*KNC(-2)+K95*KNC(-1)+K96*[illegible](-2)

NOB = 17 NOVAR = 5
RANGE = 1958 TO 1974
RSQ = 0.99962 CRSQ = 0.99949 F(4/12) = 7835.340
SER = 0.09[illegible]7 SSR = 0.105 DW(0) = 1.82

GLS PARAMETERS

MA01 0.9997

COEF	VALUE	ST ER	T-STAT
K90	-12.93330	2.03702	-6.34910
K93	-0.00918	0.01012	-0.90657
K94	-0.85210	0.10[illegible]	-7.85516
K95	1.43316	0.11911	12.03190
K96	0.27753	0.04324	6.41847

COEF	METHOD	PARAMETERS
ALL	GLS	MAV1

Equation # 22 - American Newsprint Capacity

KNU = K100+K101*CIRCUS(-2)+K103*UCAD(-2)/EXCU(-2)+K102*P[illegible](-2)+K104*P4(-2)+K105*KNU(-2)+K106*KNU(-1)

NOB = 17 NOVAR = 7
RANGE = 1958 TO 1974
RSQ = 0.9996[illegible] CRSQ = 0.99949 F(6/10) = 5193.43[illegible]
SER = 0.0453 SSR = 2.053E-02 DW(0) = 1.92

GLS PARAMETERS

MA01 1.0000

COEF	VALUE	ST ER	T-STAT
K100	-2.62595	2.36910	-1.19285
K101	0.09196	0.02924	3.14551
K102	1.45183	0.74787	1.94127
K103	-2.49932	1.06756	-2.34021
K104	-0.03682	0.01120	-3.28762
K105	-0.37501	0.14365	-2.61063
K106	0.[illegible]	0.14[illegible]	6.[illegible]

COEF	METHOD	PARAMETERS
ALL	GLS	MAV1

Equation # 18 - Canadian Woodpulp Capacity

```
     KWC = K60+K61*GNEUS8(-2)+K62*R5(-2)+K63*KWC(-1)


NOB = 17       NOVAR = 4
RANGE =  1958 TO 1974
RSQ =    0.99789       CRSQ =    0.99741      F(3/13) =  2051.040
 SER =   0.2740        SSR =      0.976       DW(0) =  1.91


GLS PARAMETERS

RHO1     0.2655

COEF            VALUE            ST ER          T-STAT

K60           -2.65194          0.51132        -5.18639
K61           27.12140          4.10021         6.61463
K62           -0.01681          0.02651        -0.63405
K63            0.28416          0.11479         2.47547


COEF      METHOD     PARAMETERS

ALL         GLS       MAV1
```

Equation # 36 - Ontario Newsprint Capacity

```
     KNO = N60+N62*CIRCUS(-2)+N63*UCACO(-2)*EXCU(-2)/WP1U(-2)+N64*R2(
-2)+N65*KNO(-1)+N66*KNO(-2)


NOB = 17       NOVAR = 6
RANGE =  1958 TO 1974
RSQ =    0.99764       CRSQ =    0.99656      F(5/11) =    928.641
SER =    0.0255        SSR = 7.164E-03        DW(0) =  2.14


GLS PARAMETERS

RHO1     1.0000

COEF            VALUE            ST ER          T-STAT

N60           -1.46222          0.24313        -6.01415
N62            0.04817          0.00768         6.27559
N63           -0.04642          0.05843        -0.79443
N64           -0.00494          0.00256        -1.93065
N65            0.60555          0.18493         3.27450
N66           -0.24304          0.10020        -2.42544


COEF -    METHOD     PARAMETERS

ALL         GLS       MAV1
```

APPENDIX III

Appendix III describes simulation tests that were conducted and presents the results of these tests.

1. Control Simulations

The complete model was simulated over the period 1958 to 1974 without any shocks in order to test the capacity of the model to track actual historical values. Estimated values from the current period are used for lagged endogenous variables in the subsequent period. Prediction errors are, therefore, cumulative so that any tendency to divergence is tested.

Table III-1 reports test statistics for the tracking error of all endogenous and two definition variables. The root mean squared percentage error exceeds 5% in only five cases: MC, PNU, QOTHER, QOTHERO, XWVR. Three of these are output variables which are important for the purpose of policy analysis. The tracking error for total Canadian and Ontario industry output is quite low and errors in the components of output do not contribute significantly to the error in estimating aggregate output.

Actual and simulated values of some of the model's principle variables are plotted in Figures III-1 to III-16. Actual values (A) are joined by a solid line and simulated values (B) are joined by a dotted line. An underestimation of newsprint prices in the earlier years has evidently caused an overestimation of newsprint sales through the same period. Simulated values of the Canadian residual output, QOTHER, vary widely from actual data. This is probably due

TABLE III-1

A COMPARISON OF ACTUAL AND SIMULATED DATA SERIES
1958 to 1974

Variable	Description	Mean Percentage Error	Root Mean Squared Percentage Error	Standard Deviation of the Percentage Error
KNC	Canadian newsprint capacity	- .01	1.06	1.09
KNO	Ontario newsprint capacity	.05	1.26	1.29
KNU	U.S. newsprint capacity	.02	1.63	1.68
KWC	Canadian woodpulp capacity	- .03	1.34	1.38
MC	Value of inputs used by Canadian industry	.08	5.90	6.08
MCO	Value of inputs used by Ontario industry	.56	3.47	3.53
PNU	Price index for U.S. newsprint	-4.39	5.33	3.12
PPC	Price index - other paper and board	- .19	1.79	1.83
PWC	Price index - woodpulp	.51	2.82	2.86
PWK	Canadian pulp & paper mill workers	1.05	1.96	1.70
PWKO	Ontario pulp & paper mill workers	1.01	1.99	1.76
QNC	Canadian newsprint production	1.29	3.94	3.84
QNO	Ontario newsprint production	1.45	4.49	4.38
QNW	North American newsprint production	1.23	3.21	3.06
QOTHER	Residual production of Canadian pulp and paper industry	3.66	24.25	24.71
QOTHERO	Residual production of Ontario pulp and paper industry	.03	5.09	5.25
SPVR	Value of shipments - other paper and board - Canada	.49	3.69	3.77
SPVRO	Value of shipments - other paper and board - Ontario	.99	3.62	3.59
XWVR	Value of pulp wood exports	.85	5.35	5.45
QGVR	Value of shipments of total Canadian pulp & paper industry	- .78	2.90	2.88
QGVRO	Value of shipments of total Ontario pulp & paper industry	- .97	2.64	2.53

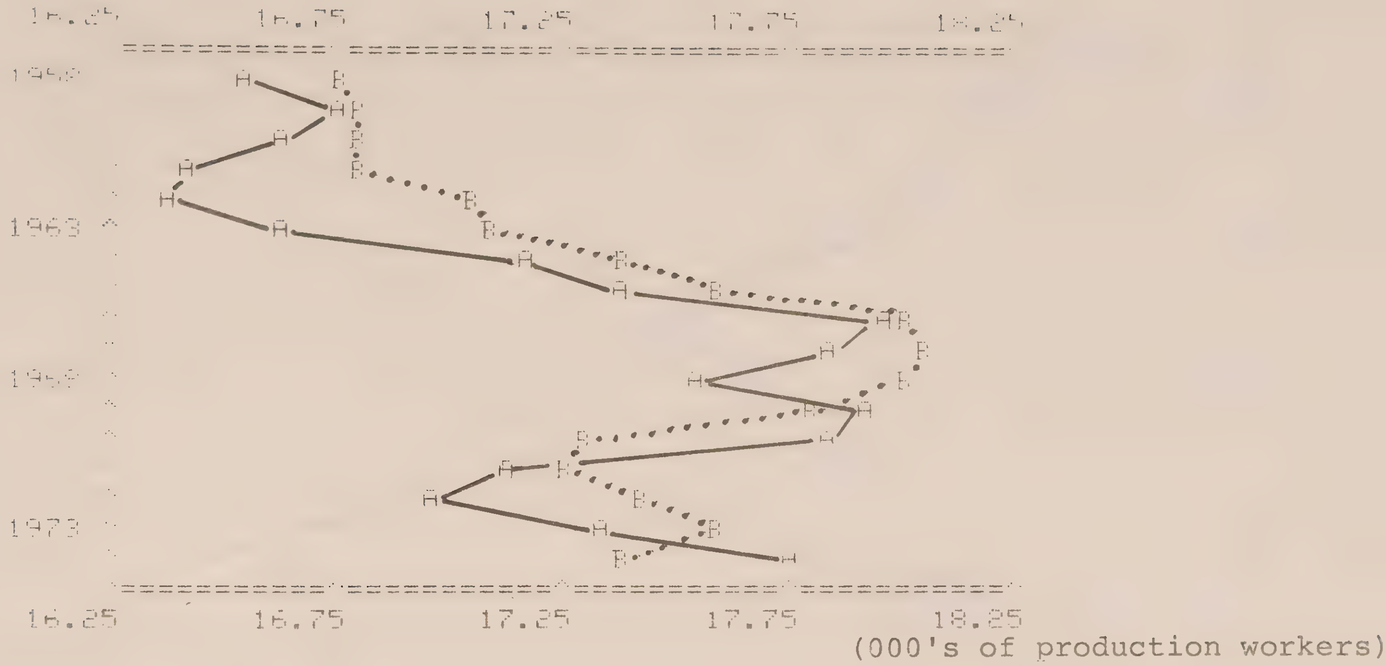


Figure III-1. PWKO actual —A— simulated ··B··

Ontario Pulp and Paper Mill Production Workers

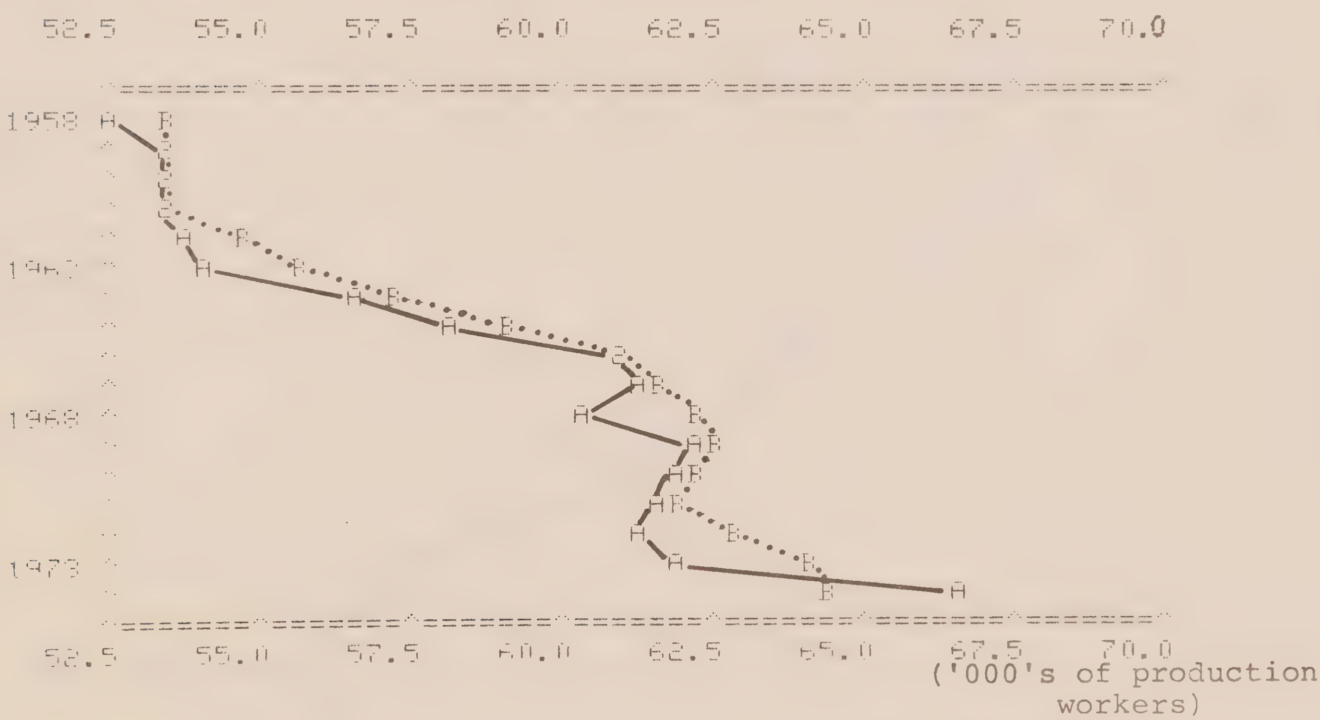
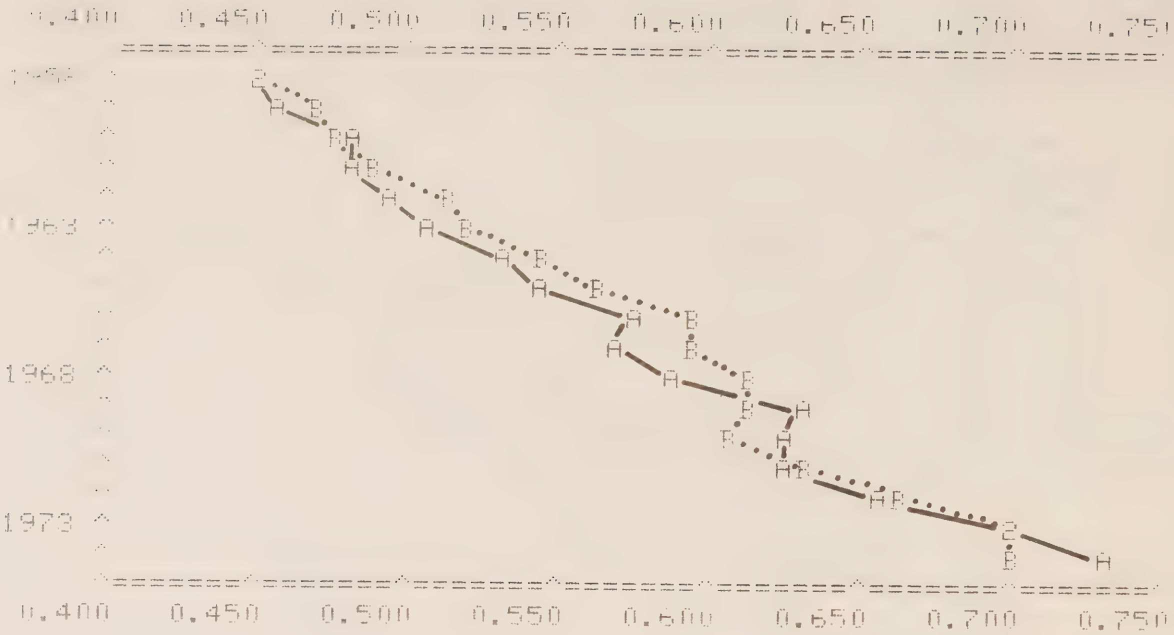


Figure III-2. PWK actual —A— simulated ··B··

Canadian Pulp and Paper Mill Workers



(billions of 1961 dollars

Figure III-3: QGVRO actual __A__
simulated ··B··

Total Ontario Output - Value of shipments of the Ontario Pulp and Paper Industry

(billions of 1961 dollar

Figure III-4· QGVR actual __A__
simulated ··B··

Total Canadian Output- Value of shipments of the Canadian Pulp and Paper Industry

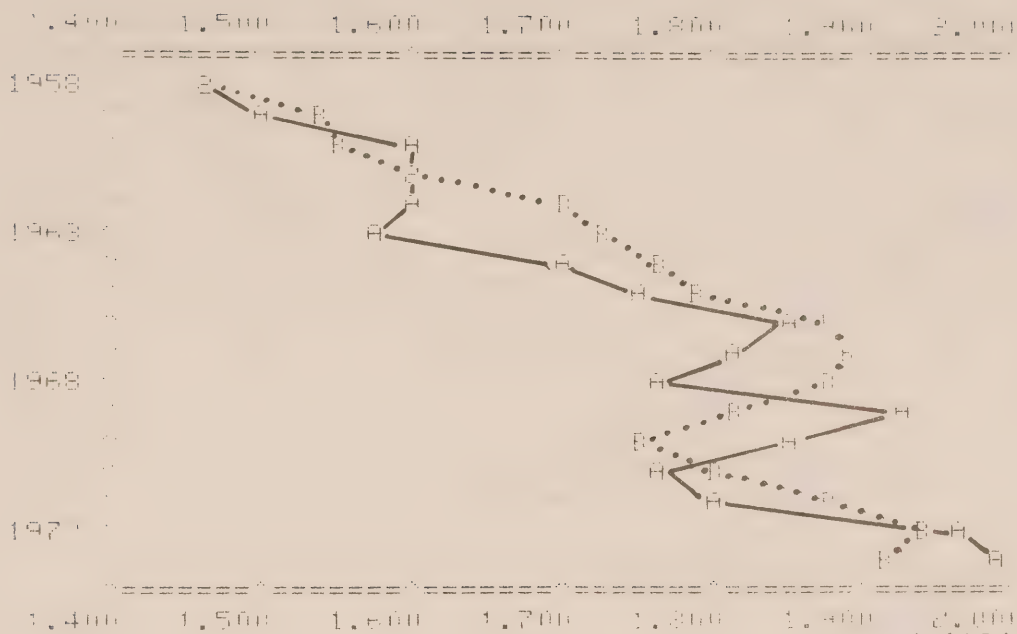


Figure III-5: QNO actual ——A——
simulated ··B··

Total newsprint production in Ontario.

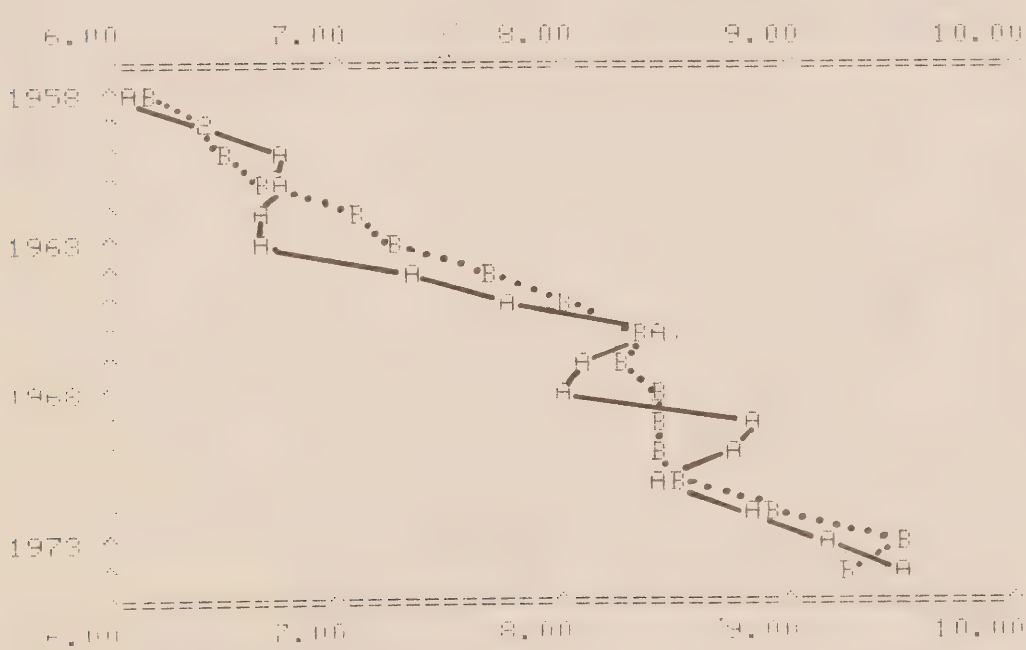
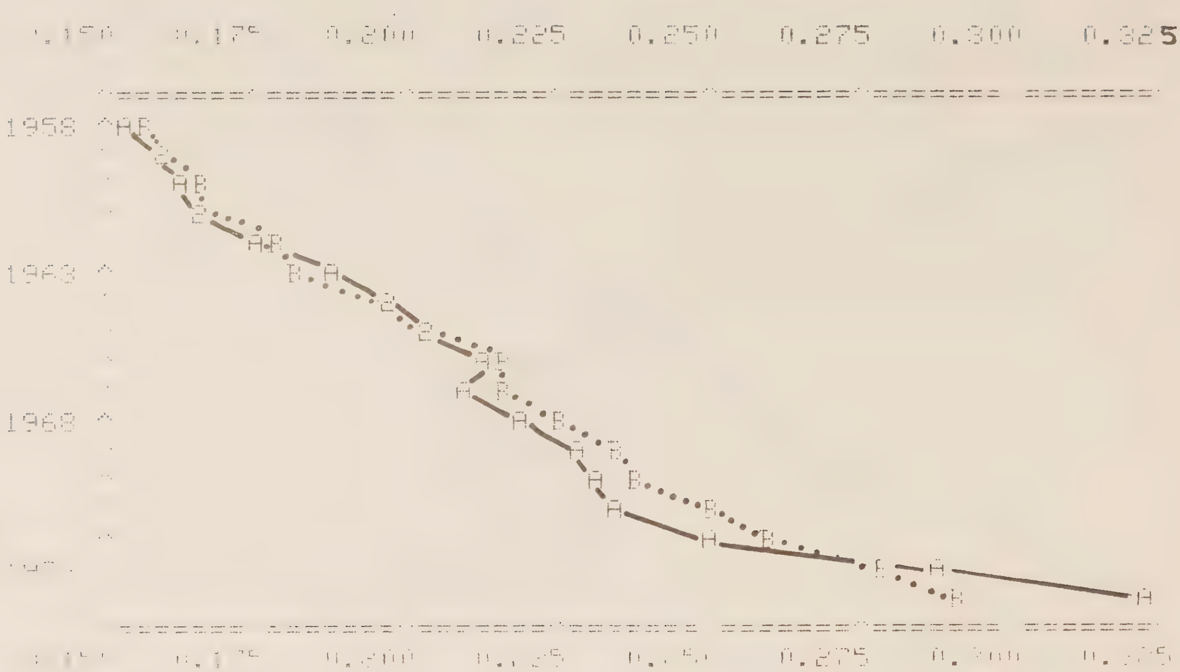


Figure III-6· QNC actual ——A——
simulated ··B··

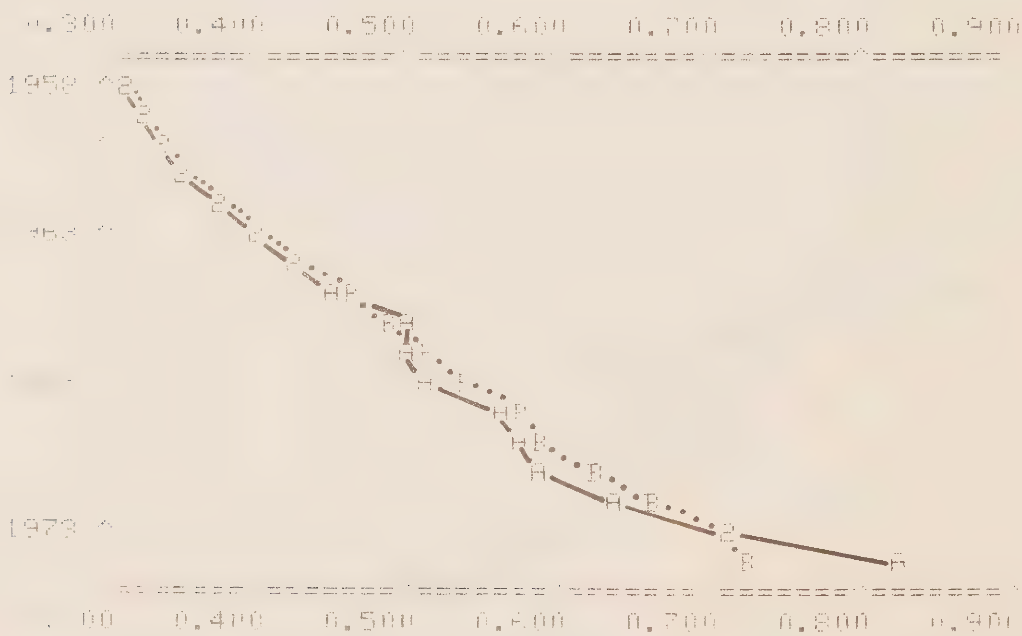
Total Canadian newsprint production



(billions of dollars)

Figure III-7· SPVRO actual ——A——
simulated ··B··

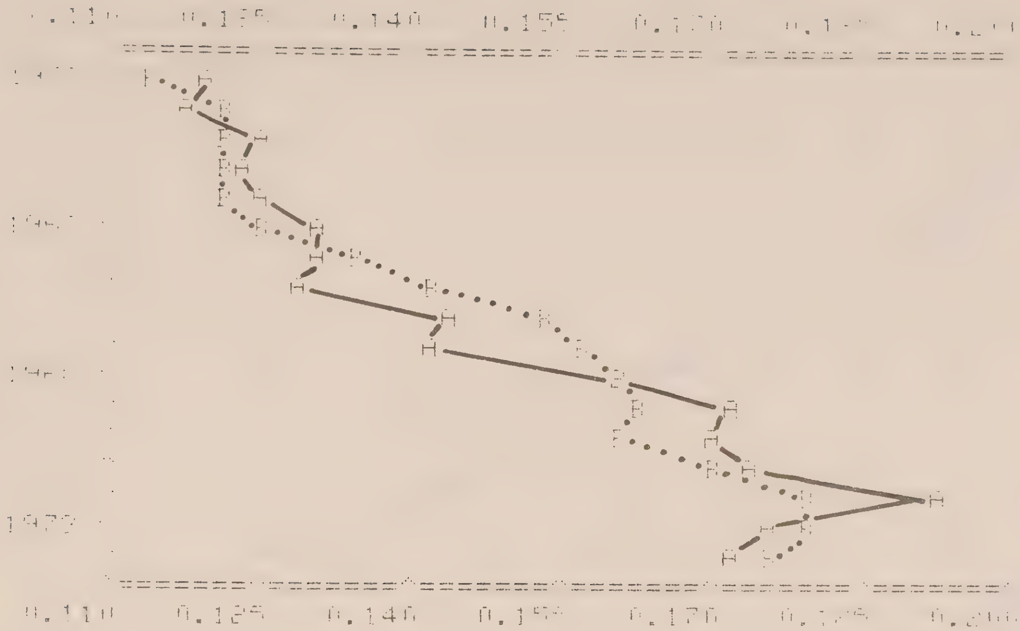
Ontario output of other paper and board - value of shipments in 1961 dollars



(billions of 1961 dollars)

Figure III-8: SPVR actual ——A——
simulated ··B··

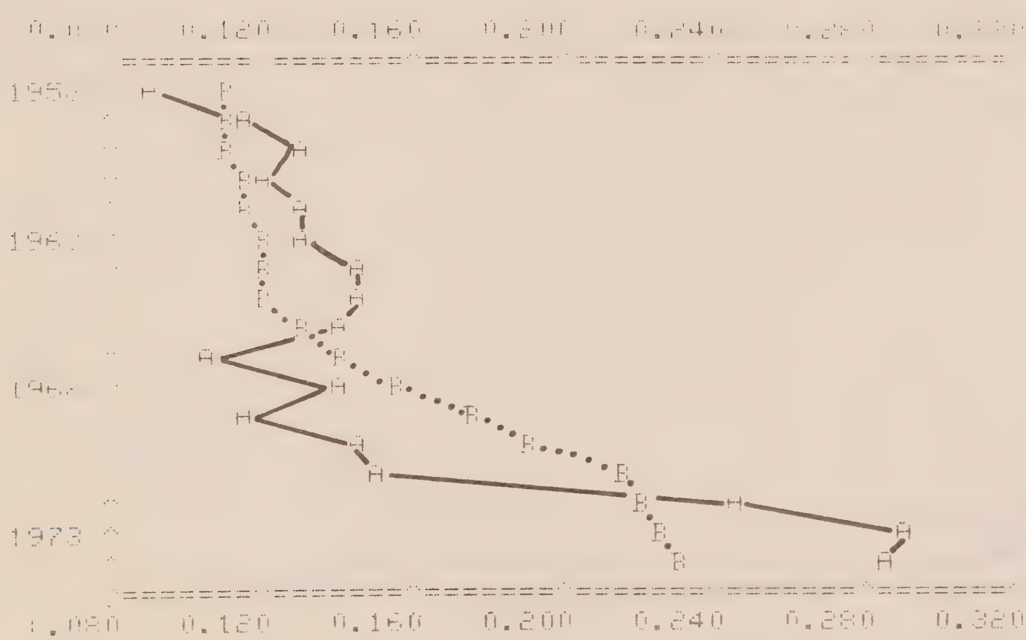
Canadian output of other paper and board - value of shipments in 1961 dollars



(billions of 1961 dollars)

Figure III-9: QOTHERO   actual   —A—
simulated   ··B··

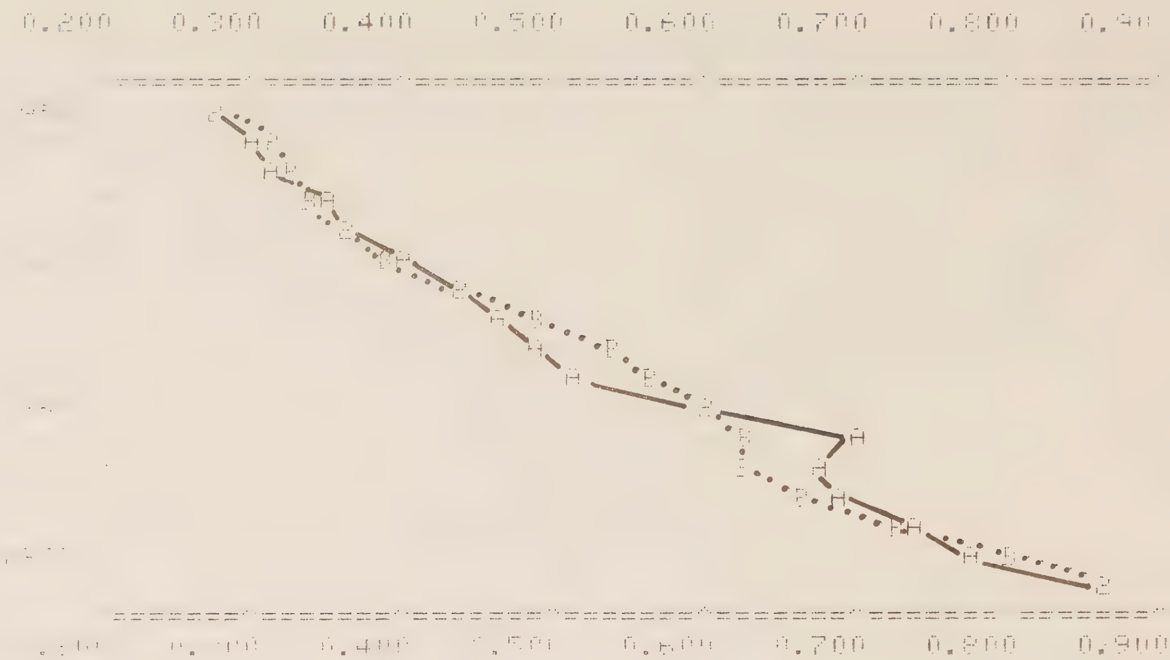
Residual production from the Ontario Pulp and Paper Industry
- 1961 dollars



(billions of 1961 dollars)

Figure III-10: QOTHER   actual   —A—
simulated   ··B··

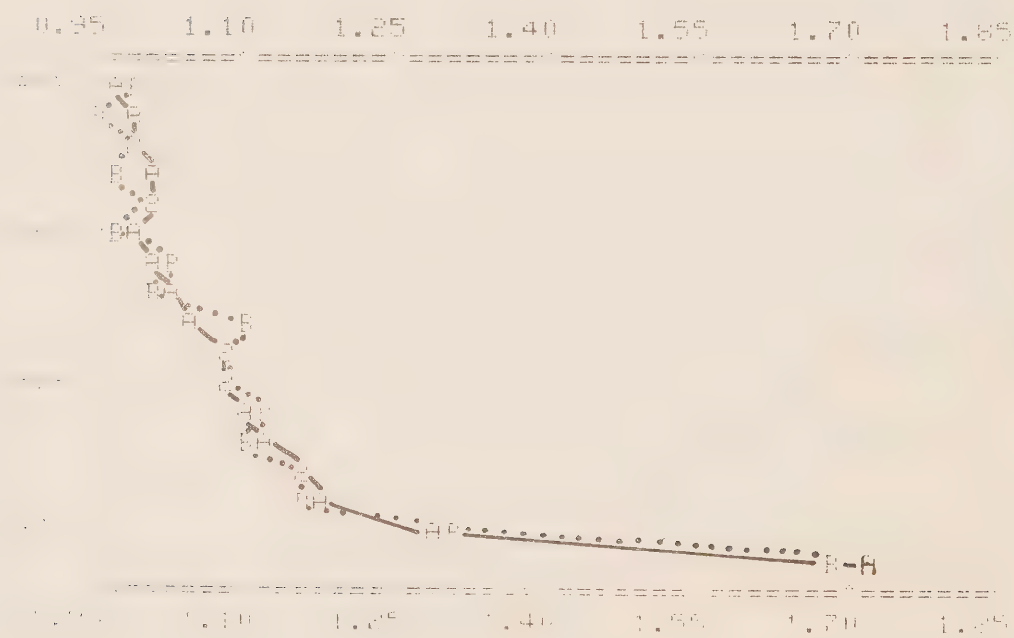
Residual production from the Canadian pulp and paper industry
- 1961 dollars



(billions of 1961 dollars

Figure III-11: XWVR actual ——A——
simulated · · B · ·

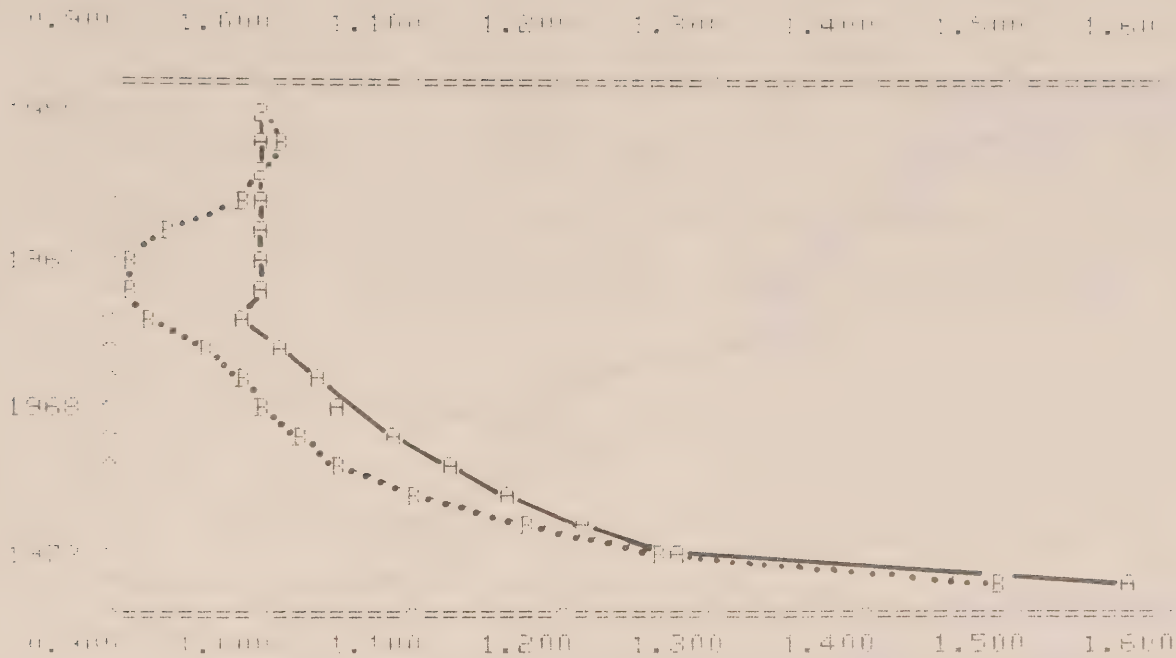
Dollar value of Canadian wood pulp exports deflated by the general wholesale prices index for wood pulp.



(price index 1961 = 1.00)

Figure III-12: PPC actual ——A——
simulated · · B · ·

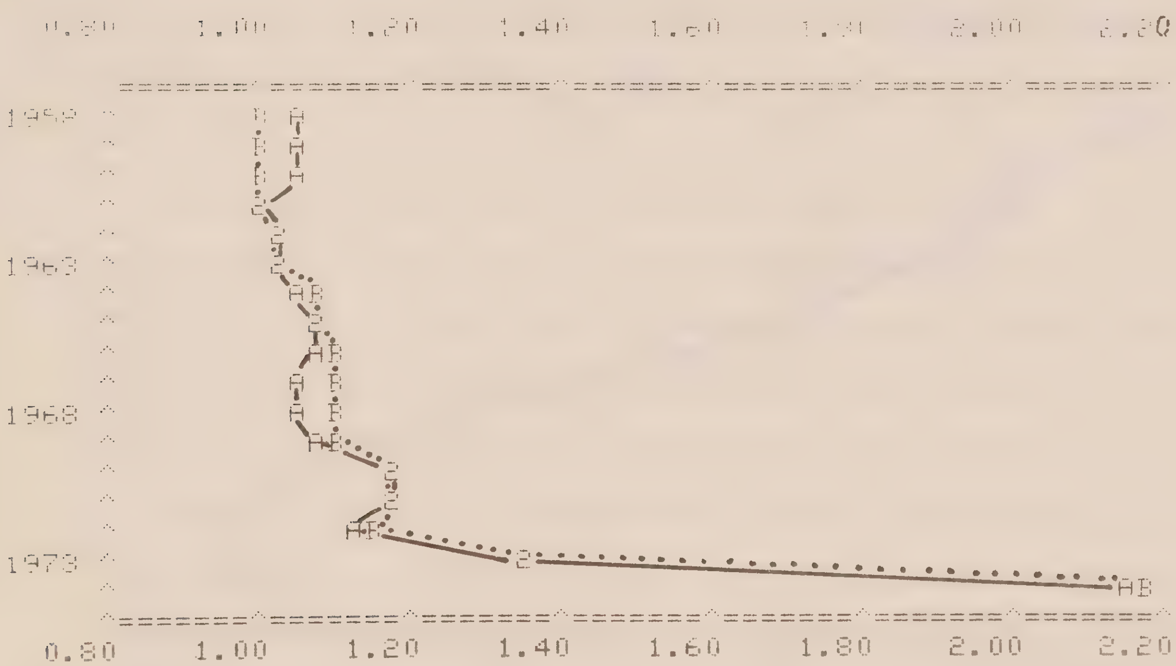
Industry selling price, index for other paper and board, 1961 = 1.00



(prices index 1961 - 1.00)

Figure III-13: PNU actual ——A——
simulated · · B · ·

Selling price index for American newsprint



(price index 1961 = 1.00)

Figure III-14: PWC actual ——A——
simulated · · B · ·

General wholesale price index for wood pulp

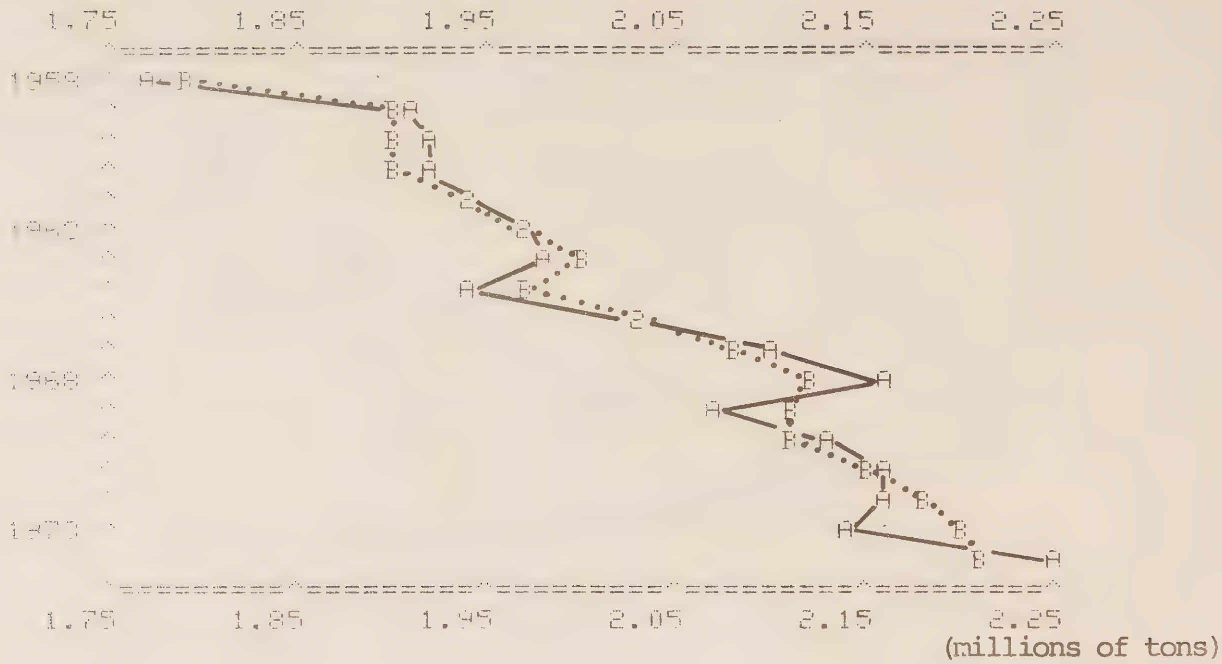


Figure III-15: KNO actual ——A——
simulated ••B••

Newsprint production capacity, Ontario

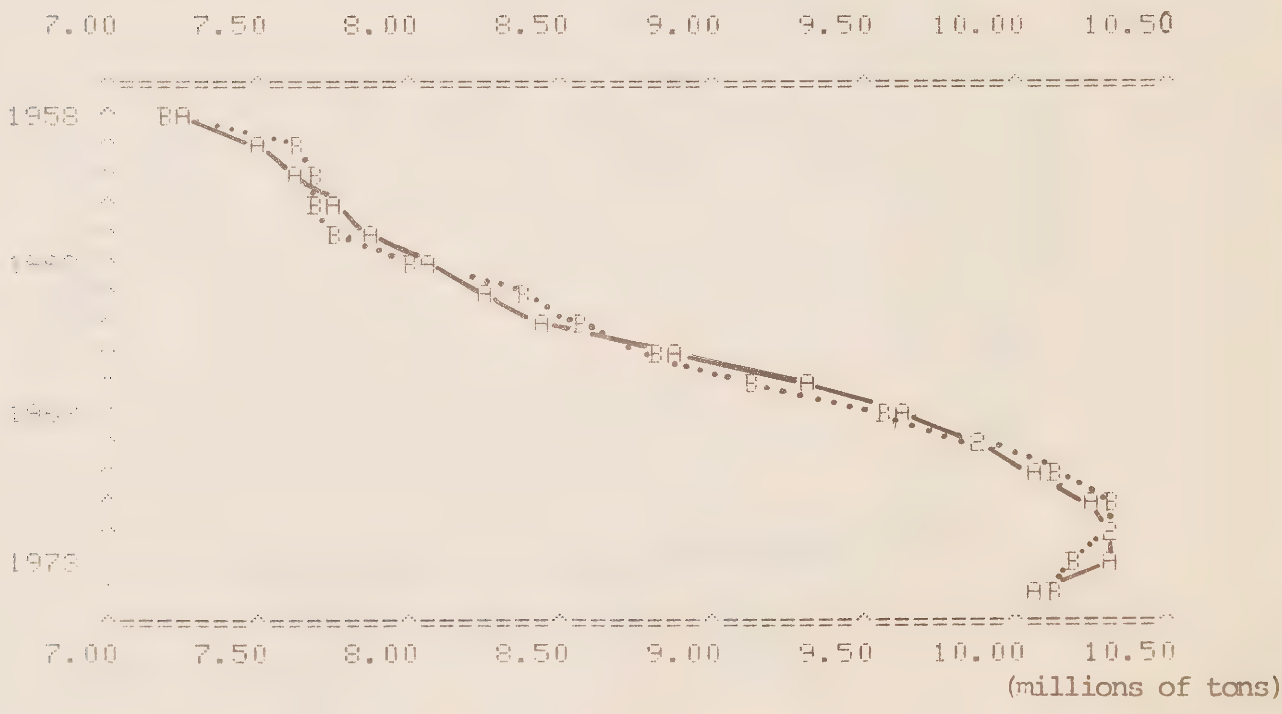


Figure III-16: KNC actual ——A——
simulated ••B••

Newsprint production capacity, Canada

to the high level of error in the reduced form equation used for estimation of QOTHER. There is little cause for concern because QOTHER constitutes a small proportion of total output. The model generally tracks other variables well.

2. Simulation Tests

More stringent pollution abatement standards can be expected to increase variable factor and capital equipment requirements without increasing total production capabilities. To simulate these effects in the model, total variable factor demands (PWK, PWKO, MC, MCO), unit variable factor costs (UCAC, UCACO, UCNUB) and the cost of capital (R2, R4, R5) were multiplied by simulation parameters which are assigned values in excess of unity. The specific tests performed are indicated in Table III-2.

The first three tests illustrate the possible consequences of pursuing pollution abatement in Ontario when similar activities are not undertaken elsewhere. Under these conditions, the competitive position of the Ontario industry will suffer. Tests four and five assume that abatement programs are undertaken throughout Canada and throughout North America, respectively. In the latter case, the simulation results suggest that there will be no loss in competitive position.

TABLE III-2

VALUES OF MULTIPLICATION PARAMETERS USED TO SHOCK

VARIABLES IN SIMULATION TESTS

		VARIABLES									
		Unit Variable Factor Costs			Cost of Capital			Total Variable Factor Demands			
	Test Name	UCAC	UCACO	UCNUB	R2	R4	R5	PWK*	PWKO*	MC	MCO
1) Ontario costs increased by 1%	PPS.01	1	1.01	1	1.01	1	1	1	1.01	1	1.01
2) Ontario costs increased by 5%	PPS.05	1	1.05	1	1.05	1		1	1.05	1	1.05
3) Ontario costs increased by 10%	PPS.10	1	1.1	1	1.1	1	1	1	1.1	1	1.1
4) Ontario & Canadian costs increased by 5%	PPS.05CA	1.05	1.05	1	1.05	1	1.05	1.05	1.05	1.05	1.05
5) Ontario, Canadian and U.S. costs increased by 5%	PPS.05US	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05
6) Sensitivity tests with same shocks as in tests 2, 4, and 5	S.D.05	1	1.05	1	1.05	1	1	1	1.05	1	1.05
	S.D.05CA	1.05	1.05	1	1.05	1	1.05	1.05	1.05	1.05	1.05
	S.D.05US	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05

* Separate simulation tests were conducted using shock variables equal to one for PWK and PWKO for tests one to five. Results from these tests are given in Table 2, pg 25.

The parameter values are statistical estimates subject to error. To allow for the possibility that the error is significant and will generate unreasonable simulation results, a worst case set of coefficients was constructed for testing. For this set of coefficients, all price elasticities in product demand and market share equations were adjusted in the direction of greater price sensitivity by increasing or decreasing the estimated value of each coefficient by one standard deviation. The resulting parameters will then generate test solution values of the endogenous variables which reflect the model's magnified sensitivity. Tests two, four and five were repeated with the altered coefficients and the results are labelled S.D.05, S.D.05CA, and S.D.05US, respectively.

The simulated abatement costs work through the model in the following manner. Canadian and Ontario cost increases raise product prices by virtue of the fixed mark-up pricing assumption. Higher prices thus depress demand in the current period. As a result, output falls and capacity utilization declines. This will have a dampening effect on the price rise in the newsprint market, but not in other product markets. The lower output in each product category implies a lower overall industry output and results in lower employment of labour and of materials, supplies and energy. A second chain of events unfolds through the capacity equations. Higher factor prices will depress capacity growth after a two-year lag. The lower capacity for newsprint

production will slow upward movements of newsprint prices. In addition, it will decrease the Canadian and Ontario shares of the North American newsprint market.

If cost increases occur only in Ontario, the Canadian equations are not affected since there are no feedbacks from the Ontario to the Canadian sectors of the model. Ontario cost increases will be cause declines in Ontario market shares, employment and capacity growth. Because total Canadian output is assumed to remain the same, the market shares of producers located in the rest of Canada increase by an amount equal to the loss suffered by Ontario producers.

If the same abatement cost increases are experienced across North America, total continental output will fall but Ontario, Canadian and American producers' market shares may rise or fall depending on the demand elasticities faced by each group.

Before presenting the simulation results, it will be useful to point out some sources of expected bias or distortion in the model:

- American product prices (PPU, PWU) are exogenous so that increases in U.S. unit costs (UCNUB) do not affect these prices. The omission of this interaction will result in an underestimation of

price increases (PPC, PWC) when costs increase across North America. This will, in turn, result in an underestimation of the impact on Canadian output of other paper and board (SPVR), and possibly of woodpulp exports (XWVR).

The overall impact of these distortions and others that undoubtably exist is difficult to ascertain. Since bias occurs in offsetting directions, the net impact should not be great. Greater reassurance can be drawn from the fact that the model does seem to capture all the major interactions apparent in the industry.

Results of the simulation tests are given in Table III-3 parts (A), (B) and (C). The first table shows the average impact of the simulation shocks over the full period. The second two tables list the first year and final year effects which are used to measure initial and long-run effects. The direction of change is reasonable in every case. Product prices rise with PPC and PNU rising by practically the full amount of the cost increase, while a greater portion of increased costs are absorbed by producers of woodpulp. These results are consistent with Muller's observation that the woodpulp sector is considerably more competitive than the newsprint sector (Muller; September, 1975; pg. 25).

TABLE III-3(A)

SIMULATION EXPERIMENT RESULTS: THE AVERAGE IMPACT OF POLLUTION ABATEMENT COST INCREASES

(% change - 1958 to 1974)

Affected Variable	Description	SIMULATION TESTS PPS .01	PPS .05	PPS .10	PPS .05CA	PPS .05US	S.D. .05	S.D. .05CA	S.D. .05US
QGVR	Total value of P & P shipments, Canada	-	-	-	- .92	- .17	-	- .60	- .96
QGVRO	Total value of P & P shipments, Ontario	-2.24	-11.18	-22.37	.02	.83	-18.75	- 1.02	- .49
QNC	Canadian newsprint production	-	-	-	-2.43	- .13	-	- 4.26	-2.22
QNO	Ontario newsprint production	- .59	- 2.96	- 5.92	- .01	1.77	- 3.41	- 2.54	-1.17
XWVR	Deflated value of woodpulp exports	-	-	-	- .24	- .24	-	- .84	- .84
QOTHERO	Residual Ontario production	-7.07	-35.38	-70.76	2.31	2.31	-61.32	2.73	2.73
SPVR	Value of shipments - other paper and and board - Canada	-	-	-	- .24	- .24	-	- .32	- .32
SPVRO	Value of shipments - other paper and board - Ontario	- .57	- 2.87	- 5.74	-1.14	-1.14	- 4.98	- 2.10	-2.10
PPC	Price index - other paper and board	-	-	-	3.18	3.18	-	3.18	3.18
PWC	Price index - woodpulp	-	-	-	1.25	1.25	-	1.25	1.25
PNU	Price index - U.S. newsprint	-	-	-	4.37	4.58	-	4.11	4.25
KNC	Canadian newsprint capacity	-	-	-	- .16	- .16	-	- .16	- .16
KNO	Ontario newsprint capacity	- .10	- .51	- 1.01	- .63	- .50	- .29	- .28	- .29
KWC	Canadian woodpulp capacity	-	-	-	- .07	- .07	-	- .07	- .07
PWK	Production workers - Canada*	-	-	-	8.74	9.54	-	.68	1.37
					(- .87)	(- .15)			
PWKO	Production workers - Ontario*	- .50	- 3.00	- 7.39	8.50	9.11	-10.90	7.66	8.21
		(-2.15)	(-10.76)	(-21.50)	(- .19)	(.40)			
MC	Value of inputs - Canada	-	-	-	5.38	6.17	-	-2.68	-2.00
MCO	Value of inputs - Ontario	-1.58	- 8.43	-18.14	4.76	5.46	-17.47	3.79	4.43

* Additional simulation tests were conducted using shock variables equal to 1.0 for PWK and PWKO. The results are given in ( ).

TABLE III-3(B)

SIMULATION EXPERIMENT RESULTS: INITITAL IMPACT OF POLLUTION ABATEMENT COST INCREASES

(% change in 1958)

Affected Variable	Description	SIMULATION TESTS PPS .01	PPS .05	PPS .10	PPS .05CA	PPS .05US	S.D. .05	S.D. .05CA	S.D. .05US
QGVR	Total value of P & P shipments, Canada	-	-	-	- .81	- .52	-	- 1.32	-1.11
QGVRO	Total value of P & P shipments, Ontario	-2.87	-14.37	-28.73	.92	1.58	-24.22	- .75	-1.14
QNC	Canadian newsprint production	-	-	-	-1.40	- .59	-	- 2.40	-1.77
QNO	Ontario newsprint production	- .42	- 2.12	- 4.25	- .14	1.51	- 2.52	- 1.06	- .05
XWVR	Deflated value of woodpulp exports	-	-	-	- .28	- .28	-	- 1.00	-1.00
QOTHERO	Residual Ontario production	-9.56	-47.82	-95.65	3.61	3.61	-77.27	4.25	4.25
SPVR	Value of shipments - other paper and board - Canada	-	-	-	- .64	- .64	-	- .85	- .85
SPVRO	Value of shipments - other paper and board - Ontario	- .81	- 4.05	- 8.09	- .19	- .19	- 7.03	- .04	- .04
PPC	Price index - other paper and board	-	-	-	5.52	5.52	-	5.52	5.52
PWC	Price index - woodpulp	-	-	-	1.48	1.48	-	1.48	1.48
PNU	Price index - U.S. newsprint	-	-	-	2.38	2.47	-	2.17	2.23
KNC	Canadian newsprint capacity	-	-	-	- .04	- .04	-	- .04	- .04
KNO	Ontario newsprint capacity	- .06	- .30	- .61	- .15	- .15	- .21	- .21	- .21
KWC	Canadian woodpulp capacity	-	-	-	- .05	- .05	-	- .05	- .05
PWK	Production workers - Canada*	-	-	-	4.58 (- .4)	4.73 (- .3)	-	.85	.74
PWKO	Production workers - Ontario*	- .63 (-1.61)	- 3.47 (- 8.07)	- 7.75 (-16.14)	5.51 (- .49)	5.77 (- .7)	- 9.40	5.42	5.65
MC	Value of inputs - Canada	-	-	-	4.32	4.56	-	- 4.30	-4.12
MCO	Value of inputs - Ontario	-2.43	-12.83	-27.36	6.08	6.61	-25.03	5.89	6.36

* Additional simulation tests were conducted using shock variables equal to 1.0 for PWK and PWKO. The results are given in ( ).

TABLE III-3(C)

SIMULATION EXPERIMENT RESULTS: LONG RUN IMPACT OF POLLUTION ABATEMENT COST INCREASES

(% change in 1974)

Affected Variable	Description	PPS .01	PPS .05	PPS .10	PPS .05CA	PPS .05US	S.D. .05	S.D. .05CA	S.D. .05US
QGVR	Total value of P & P shipments, Canada	-	-	-	- .72	- .33	-	- 1.03	- .81
QGVRO	Total value of P & P shipments, Ontario	-1.83	- 9.17	-18.35	.42	.26	-15.50	- .78	- .55
QNC	Canadian newsprint production	-	-	-	-2.31	- .87	-	- 3.08	-2.21
QNO	Ontario newsprint production	- .62	- 3.10	- 6.19	-1.47	.56	- 3.54	- 1.79	-1.11
XWVR	Deflated value of woodpulp exports	-	-	-	- .19	- .19	-	- .65	- .65
QOTHERO	Residual Ontario production	-5.94	-29.71	-59.41	1.31	1.31	-56.75	1.37	1.37
SPVR	Value of shipments - other paper and board - Canada	-	-	-	- .13	- .13	-	- .18	- .18
SPVRO	Value of shipments - other paper and board - Ontario	- .34	- 1.68	- 3.37	- .62	- .62	- 2.88	- 1.13	-1.13
PPC	Price index - other paper and board	-	-	-	3.25	3.25	-	3.25	3.25
PWC	Price index - woodpulp	-	-	-	.97	.97	-	.97	.97
PNU	Price index - U.S. newsprint	-	-	-	3.10	4.34	-	1.87	2.73
KNC	Canadian newsprint capacity	-	-	-	- .11	- .11	-	- .11	- .11
KNO	Ontario newsprint capacity	- .09	- .47	- .94	- .55	- .55	- .26	- .26	- .26
KWC	Canadian woodpulp capacity	-	-	-	- .06	- .06	-	- .06	- .06
PWK	Production workers - Canada*	-	-	-	9.54	10.01	-	3.48	3.79
					(- .78)	(- .35)			
PWKO	Production workers - Ontario*	- .10	- .95	- 3.03	8.81	9.25	- 7.96	8.16	8.44
		(-1.85)	(- 9.25)	(-18.51)	(- .34)	(- .05)			
MC	Value of inputs - Canada	-	-	-	5.69	6.11	-	- .11	- .39
MCO	Value of inputs - Ontario	-1.06	- 5.69	-12.40	4.60	5.07	-13.13	4.03	4.30

* Additional simulation tests were conducted using shock variables equal to 1.0 for PWK and PWKO. The results are given in ( ).

The negative impacts on capacity growth in Ontario are, with one exception, all less than 1%. Ontario employment and output variables decline by more than 5% only for tests in which Ontario production costs alone are increased and where the increase is greater than 1%. In particular, the effect on Ontario pulp exports (QOTHERO) is relatively strong, again supporting the proposition that the woodpulp sector is competitive. The exact magnitude of the impact on QOTHERO is suspect because of the degree of error in the relevant equation. The impact on Canadian employment and output is significantly different from zero only for those tests which alter Canadian production costs in addition to Ontario production costs. The simulated variables all drop by less than 5% and usually by less than 1%.

The effect on Ontario variables is significantly reduced when production costs are increased for producers outside Ontario as well as inside. In the case of continental cost increases, PPS.05US, Ontario producers actually increase output at the expense of other Canadian and American producers. We get this result because of the configuration of price elasticities in Ontario market share equations. Given the error of the underlying specifications, it is better to interpret these estimated increases in Ontario output as evidence that the consequences of cost increases on Ontario producers will be negligible.

Changes in employment are generally less than changes in output when it is assumed that there is an offsetting demand for labour resulting from abatement activities. Where cost increases apply to the rest of Canada or the U.S. as well, Ontario mills do not lose workers even if pollution abatement activities are assumed to generate no employment whatsoever.

In general, these simulation results reaffirm Muller's conclusion that output and employment in the Canadian pulp and paper industry is relatively insensitive to exogenous changes in cost (Muller, September 1975; p.25). On the other hand, the Ontario share of Canadian markets seems to be quite sensitive in competitive sectors of the industry (i.e., woodpulp), but insensitive in the relatively non-competitive sectors (i.e., other paper and board). This conclusion is tentative and requires a more rigorous investigation of regional competition in Canada to be verified.

A similar pattern of responses was obtained with simulations that used the price coefficients altered by one standard deviation. Woodpulp exports change substantially when costs were altered in Ontario alone and this resulted in significant shifts in employment. However, when cost changes were experienced in the rest of Canada and the U.S. as well, which is the more realistic situation, Ontario output and investments decreased by less than 5% and employment increased. While changes in price elasticity have an effect, they were not great and the conclusion of the preceding paragraph holds.

APPENDIX IV

This Section Describes Some Additional Simulation Tests which can be Performed with the Econometric Model Described in this Study

The following simulation tests can be performed on the econometric model of the P & P industry described in this study.

A. <u>Increased Capital Requirements for Pollution Abatement</u>

1. In Ontario alone, multiply user costs of capital in Canada (CC in equation 14) by a shift parameter.

2. In Canada (not Ontario) multiply CC in equation 17 by a shift parameter.

3. In the U.S. alone, multiply user cost of capital in the U.S. (CU in equation 16) by a shift parameter.

4. In separate sectors of the industry, multiply the capital cost variables (R2, R5, and R4) in each capacity equation (equations 18, 21, 22 and 36) by the appropriate shift parameters. Equation 21, 22 and 36 are all in the newsprint sector and would thus have the same shift parameters.

B. <u>Capital Assistance Program:</u>

Reconstruct CC or CU to incorporate the effect of the program. The formula for these variables is:

$$CC, CU = P_k (r + s) - \Delta P_k$$

where: P_k == price of capital

r == interest rate

s == rate of depreciation of real equipment

ΔP_k == change in the price of capital.

If, for instance, a proportion of capital equipment, a , is to be given special consideration by means of low interest rates, r', then the new formula would be:

$$CC = P_k (ar' + (1-a)r + s) - \Delta P_k$$

C. Increased Variable Costs for Pollution Abatement:

1. Labour requirements and materials, supplies, and energy requirements rise, therefore, multiply the unit cost variables (UCAC, UCACO and/or UCNUB) by a shift parameter and multiply through the variable factor demand equations by the same amount (PWK, PWKO, MC, MCO).

2. Only labour requirements rise, therefore, increase PWK and/or PWKO along with ANC and/or ANCO by multiplying through equations 11, 29, 6 and 31.

3. Only materials, supplies and energy requirements rise, thus increase MC and/or MCO along with AMC and/or AMCO by multiplying through equations 20, 30, 7 and 32.

D. Tariff Policies

1. Imports of Other Paper and Board:

   The tariff on other paper and board imports, TPC, is used in the construction of PLPC. Multiplying TPC by a shift parameter would simulate an increase in the tariff. A proper simulation of this policy requires first that PLPC be entered successfully in the demand equation for other paper and board, equation 13. It should have a positive sign. Without this, a shift in TPC will only be useful in revealing the impact of tariffs on the domestic price, PPC.

2. Exports of Woodpulp:

A tariff imposed on exports of woodpulp, XWVR and QOTHERO, can be simulated by increasing the Canadian price variables in equations 24 and 37; these are PWC/EXCU/WPIU, UCACO/EXCU/WPIU, UCAC/EXCU/WPIU.

E. Changes in Canadian and American National Income:

Multiply GNEC61 and/or GNEU58 by the appropriate shift parameter in the product demand and capacity equations. This is not a reliable test because the relationship between national income and other exogenous variables such as newspaper circulation and wages is not modelled.[11]

F. Changes in the Exchange Rate

Multiply the exchange rate variable, EXCU, by the shift parameter wherever it appears in the model (or multiply the original data series that is used by the model).

G. Effluent Charges:

Make explicit assumptions about the relationship between unit outputs and effluent emissions and then simulate a tax on effluents by raising unit costs (UCAC, UCACO, UCNUB) to reflect the output of associated effluents and the level of effluent charges under consideration. Factor requirements are not altered.

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11 Muller (1975), pg. 137.

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